GEOLOG ALF

GLACI

T

GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA. ALFRED R. C. SELWYN, C.M.G., LL.D., F.R.S., DIRECTOR.

REPORT

OF EXPLORATION OF THE

GLACIAL LAKE AGASSIZ IN MANITOBA.

BY

WARREN UPHAM.



PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
WILLIAM FOSTER BROWN & CO.
1890.

To A. R. C. SEL Director of the C SIR,—I herewi

area of the glacis performed in May Canada and for accordance with charge of the Gl of this lacustrine been examined b

> as complete as p made by the Dir include within my by Lake Agassiz. Besides the prain to have included a together with the

deemed very designation design

of the five great La this report shows shows its portion of marking the succe

its whole area bei

beine deltas.

Elevations deteilosis of my levellirailway profiles and ledgments are due.

Pratt of Winnipeg George, H. Wobst.

George H. Webste and Northwestern in charge of gover Dr. Robert Bell, ye

Somerville, Mass

To A. R. C. SELWYN, C.M.G., LL.D., F.R.S.,

Director of the Geological and Natural History Survey of Canada.

Sir.—I herewith submit to you my report of observations on the area of the glacial Lake Agassiz in Manitoba. This exploration was performed in May, June and July, 1887, for the Geological Survey of Canada and for that of the United States, under which latter, in accordance with instructions from President T. C. Chamberlin in charge of the Glacial Division of that Survey, the southern portion of this lacustrine area, lying in Minnesota and North Dakota, had been examined by me during the two preceding summers. It was deemed very desirable to continue the exact mapping and levelling along its beaches northward into Manitoba for the purpose of making the final report on this subject for the United States Geological Survey as complete as possible; and arrangements providing for this were made by the Director of that Survey and yourself, enabling me to include within my examination all the prairie region that was occupied by Lake Agassiz.

Besides the prairie district thus examined, this glacial lake is believed to have included a much larger wooded region on the north and east, together with the present lakes Winnipeg, Manitoba, and Winnipegosis, its whole area being probably somewhat more than the combined areas of the five great Laurentian lakes. One of the two maps accompanying this report shows this probable extent of Lake Agassiz; and the other shows its portion examined in Manitoba, with the course of its beaches, marking the successive stages of the lake, and the Pembina and Assinibine deltas.

Elevations determined by railway surveys have been taken as the basis of my levelling along the beaches. For opportunity to examine railway profiles and for manuscript notes of them, my grateful acknowledgments are due to Mr. P. A. Peterson of Montreal and Mr. R. M. Pratt of Winnipeg, engineers of the Canadian Pacific Railway, to Mr. George H. Webster of Portage la Prairie, engineer of the Manitoba and Northwestern Railway, to Mr. Collingwood Schreiber of Ottawa, in charge of government railways, and to Dr. George M. Dawson and Dr. Rebert Bell, your associates in this survey.

I have the honor to be,

Sir,

Your obedient servant.

WARREN UPHAM.

Somerville, Mass., June, 1889.

GLACIAL

Among the most in America are the

extent, which are within the basin ancient area. Lal and Lake Lahonta Lake, Nevada, are lakes, formed by i the lakes to small across which they glaciated area of existence to the ch the glacial epochs basin of the Red I another class of th the ice-sheet when land surface. Suc. basins of Lake Wir of the ice-border, warmer climate;

Merjelen See, pen Great Aletsch glac Greenland. On the western

same kind then flowater-sheds. Exa

in the glacial drift one mile and a half

REPORT

OF EXPLORATION OF THE

GLACIAL LAKE AGASSIZ IN MANITOBA.

INTRODUCTION.

Among the most important geologic records of the Quaternary period in America are the sediments and shore lines of former lakes of great extent, which are now represented by lakes that occupy, excepting within the basin of the Saint Lawrence, only a small part of their ancient area. Lake Bonneville in the basin of Great Salt Lake, Utah, and Lake Lahontan in the basin of the Humboldt River and Pyramid Lake, Nevada, are conspicuous examples of one class of these Quaternary lakes, formed by increased rain-fall where now an arid climate limits Two classes of the lakes to small areas, with their surface far below the water-sheds lakes. across which they would outflow to the sea. These are south of the glaciated area of the continent, but they appear to have owed their existence to the changes of climate by which the supposed ice-sheets of the glacial epochs were formed. Lake Agassiz, which occupied the basin of the Red River of the North and Lake Winnipeg, belongs to another class of these lakes, caused directly by the supposed barrier of the ice-sheet where this was accumulated on a northwardly sloping land surface. Such glacial lakes were developed on a vast scale in the basins of Lake Winnipeg and the Laurentian lakes during the recession of the ice-border, when it was being gradually melted away by a warmer climate; and it is also evident that many small lakes of the same kind then flowed southward over the lowest points of the present water-sheds. Examples of this class now existing are the little Merjelen See, pent up in a tributary valley on the east side of the Great Aletsch glacier in the Alps, and similar ice-dammed lakelets in Greenland.

On the western boundary of Minnesota a remarkable valley is eroded in the glacial drift to the depth of 125 to 150 feet with a width of about one mile and a half, extending from north to south across the lowest

Channel of outlet from Lake Agassiz.

The Red River Valley.

part of the water-shed that divides the basin of the Red River of the North from that of the Mississippi. This channel has been evidently the course of a great river since the drift was deposited. After the river ceased to flow here, portions of the bottom of the valley have become filled to the slight depths of ten or twenty feet by alluvial beds brought in by tributary streams, and the intervening portions of the old valley are occupied by the long, narrow and shallow Lakes Traverse and Big Stone, the former outflowing northward by the Bois des Sioux to the Red River, and the latter southward by the Minnesota River to the Mississippi. The general level of the land on each side of this water-course is about 1,100 feet above the sea; the heights of Lakes Traverse and Big Stone are respectively 971 and 963 feet above the sea; and the lowest point of the divide between them, in Brown's Valley, is only three feet above Lake Traverse. A valley of similar size extends all along the course of the Minnesota River; but toward the north the broad water-course, with the adjoining highland on each side, ends within a few miles.

The country north of Lake Traverse sinks gradually to a level not

much above the small Bois des Sioux River, which flows north 35 miles. emptying into the Red River of the North at Breckenridge and Walpeton. The Red River, here turning abruptly from its western course, flows thence north to Lake Winnipeg, 285 miles. These streams occupy the axial depression of a vast plain of glacial drift and lacustrine and fluvial deposits, forty to fifty miles wide and more than 300 miles long, stretching from Lake Traverse to Lake Winnipeg. This expanse widely famed for the large harvests and superior quality of its wheat, is commonly called the Red River Valley. It has a very uniform continuous descent northward, averaging a little less than one foot per mile. So slight an inclination is imperceptible to the eye, as is also the more considerable ascent, usually two or three feet per mile, for the first ten or fifteen miles to the east and west from the Red River This river flows along the lowest portion of the plain, somewhat east of its central line, in a quite direct general course from south to north but meanders almost everywhere with minor bends which carry alternately a half mile or one mile to each side of its main course, has cut a channel twenty to fifty feet deep and is bordered by only fer and narrow areas of bottomland, instead of which its banks usually rise steeply on one side and by moderate slopes on the other, to the lacustrine plain which thence reaches nearly level ten to thirty mile from the river.

Where the surface rises on each side of this expanse, definite and continuous beach deposits are found marking the shore lines of a val lake which formerly covered the Red River Valley and by its outfor

Thi

eroded the dec described. ence to glacial c of an ice-sheet v When this cont was yielding its drainage from it of the land is no beyond the water Rivers, it is evid foot of the ice fie the Red River Va of the lowest poi barrier was so fa Hudson Bay that its outlet was alo of its relation to named in memor advocate of the th the past fifteen ye demonstrated by deposits that wer ce-sheet, extending nd Long Island. Ilinois, Wisconsin The characters of skers, also the gli fland ice as their he Red River Val he basins of the ontemporaneous

The evidences of iver Valley were st scientific expe alliser, in 1858 Geological and Natura

e River St. Law

Narrative of an Expec

ds, &c., performed in g. U. S. Topographica Report of a Geological Journals, detailed repo Report of the Assimbo 67, 168. Report on the Geolog

lel, from the Lake of

River of the en evidently . After the valley have alluvial beds rtions of the kes Traverse ois des Sioux sota River to side of this ghts of Lakes feet above the n, in Brown's ley of similar ; but toward hland on each

to a level not north 35 miles. idge and Wahvestern course, streams occupy lacustrine and han 300 miles This expanse, ty of its wheat, ry uniform conn one foot per e eve, as is also et per mile, for the Red River. , somewhat east south to north

which carry

nain course. I

red by only fer

s banks usually

he other, to the n to thirty mile

nse, definite and e lines of a vas nd by its outflor

eroded the deep channel extending thence southward as already described. This lake is believed by the writer to have owed its existence to glacial conditions during the final melting and gradual recession of an ice-sheet which overspread the northern half of North America. When this continental glacier, subdued by a more temperate climate, was vielding its ground between Lake Traverse and Hudson Bay, free drainage from its south side could not take place, because the descent Lake Agassiz of the land is northward. As soon as the border of the ice had receded receding beyond the water-shed dividing the basins of the Minnesota and Red Rivers, it is evident that a lake, fed by the glacial melting, stood at the foot of the ice fields and extended northward as they withdrew along the Red River Valley to Lake Winnipeg, filling this valley to the height of the lowest point over which an outlet could be found. Until the ice harrier was so far melted upon the area between Lake Winnipeg and Hudson Bay that this glacial lake began to be discharged northward, its outlet was along the present course of the Minnesota River. Because of its relation to the retreating continental ice-sheet, this lake has been named in memory of Professor Louis Agassiz, the first prominent advocate of the theory that the drift was produced by land ice.1 Within the past fifteen years the truth of this explanation of the drift has been demonstrated by the recognition and detailed study of the morainic teposits that were accumulated along the southern boundary of the ce-sheet, extending from Nantucket, Martha's Vineyard, Cape Cod, nd Long Island, across New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Minnesota, Iowa, and South and North Dakota. the characters of other drift deposits, as the till and the kames and skers, also the glacial striæ, point with equal certainty to a vast sheet fland ice as their cause; and the explanation accounts for this lake in he Red River Valley, for similar lakes that were tributary to it from he basins of the Souris and South Saskatchewan Rivers, and for the ontemporaneous higher levels of the great lakes now discharged by e River St. Lawrence.

The evidences of the former existence of a great lake in the Red iver Valley were observed in 1823 by Keating, the geologist of the Earlier st scientific expedition to this district,2 in 1848 by Owen,3 in 1857 by observers. alliser, in 1858 by Hind, and in 1873 by Dr. G. M. Dawson. The

Geological and Natural History Survey of Minnesota, Eighth annual report, for the year 1879,

Narrative of an Expedition to the source of St. Peter's River, Lake Winnepeek, Lake of the ds. &c., performed in the year 1823, under the command of Stephen H. g, U. S. Topographical Engineer. London, 1825. Vol. ii, p. 3.

Report of a Geological Survey of Wisconsin, Iowa, and Minnesota. Philadelphia, 1852. p. 178, Journals, detailed reports, &c., presented to Parliament, 19th May, 1863, p. 41.

Report of the Assimboine and Saskatchewan Exploring Expedition. Toronto, 1859. pp. 39,

eport on the Geology and Resources of the Region in the Vicinity of the Forty-ninth liel, from the Lake of the Woods to the Rocky Mountains. Montreal, 1875. p. 248.

exeavation of the valley occupied by Lakes Traverse and Big Stone and the Minnesota river was first explained in 1868 by Gen. G. K. Warren, who attributed it to the outflow from this ancient lake. He made a careful survey of this valley, and his maps and descriptions, with the accompanying discussion of geologic questions, are most valuable contributions to science. After his death, in commemoration of this work the glacial river that was the outlet of Lake Agassiz was named River Warren. That this lake existed because of the barrier of the receding ice-sheet was first pointed out in 1872 by Prof. N. H. Winchell.

Previous work in the United States.

The part of the area of Lake Agassiz which lies in Minnesota, so far as it is prairie, was explored by the writer in 1879 and 1881, under the direction of Prof. N. H. Winchell, State Geologist, with the assistance in 1881 of Horace V. Winchell as rod-man in levelling. Further exploration of this lake was carried forward in 1885 and 1886 for the United States Geological Survey by the writer, under the direction of Pres. T. C. Chamberlin, with Robert H. Young as assistant, mapping the upper or Herman beaches in North Dakota from Lake Traverse to the international boundary, besides portions of the lower shore line both in North Dakota and Minnesota, with exact determinations of their elevation by levelling. A preliminary report of part of these observations was published in 1887.

By co-operation of the Geological Surveys of the United States and Canada, a portion of my field-work in 1887 was devoted to the examination of the northward extension of the beaches of Lake Agassiz 4 Manitoba. Travelling with horse and wagon, and assisted by Man Young as in the two preceding years, a somewhat detailed exploration of this lacustrine area was continued about a hundred miles north from the international boundary, the most northern points reached being

Continuation in Manitoba.

1"On certain physical features of the Upper Mississippi River," American Naturalist, vol.2 pp. 497-592, November, 1898. Annual Report of the Chief of Engineers, United States Arunda 1868, pp. 307-314. "An essay concerning important physical features exhibited in the valley the Minnesota River, and upon their signification," with maps, Report of Chief of Engineer 1875. "Valley of the Minnesota River and of the Mississippi River to the junction of the Oh. Its origin considered—depth of the bed rock," with maps, Report of Chief of Engineer, 13 and American Journal of Science, III, vol. xvi, pp. 417-431, December, 1878. (General Ward Lied August 8, 1882.)

2 Proceedings of the American Association for the Advancement of Science, vol. xxxii, in 1833, pp. 213-231; also in American Journal of Science, III, vol. xxvii, Jan. and Feb., 1831; m Geology of Minnesota, vol. i, p. 622.

² First Annual Report of the Geological and Natural History Survey of Minnesota, for P. p. 63; and Sixth Annual Report, for 1877, p. 31. Professor Winchell also explained in its manner the formerly higher levels of the Laurentian lakes, Popular Science Monthly, 4m 1873; and the same view is stated by Prof. J. S. Newberry in the Report of the Geological Surg of Ohio, vol. ii, 1874, pp. 6, 8, and 51.

⁴ Geological and Natural History Survey of Minnesota, Eighth Annual Report, for 1872, pp. 87; Eleventh Annual Report, for 1882, pp. 137-133, with map; and Final Report, vols. i and it a United States Geological Survey, Bulletin No. 39. The Upper Beaches and Deltas of Glacial Lake Agassiz. pp. 34, with map.

Shoal Lake, be Ridge post-offic wooded characte ling and tracing condition limited ing the Red Riv is formed by th Hills, and Ridin, Brandon during observations wer include the vicin way to Griswold, Lang's Valley, a Souris southeast course of that riv margin of Lake . ary. The breadt about a hundred The upper or height determine Traverse east to I east-southeast of (

ing an extent of Dakota this shore of the Red River Lake Traverse to thence in a nearly tional boundary. district supplied r and in many insta the beaches of this reference points entire extent to b ment with the rai vals varying fron methods were em of the Canadian **F** Northwestern ngineers of these

of the elevations

eport and in the

ea level at mean

arveys from the

Big Stone and K. Warren, . He made a ions, with the valuable conof this work named River f the receding nchell.

nnesota, so far 881, under the the assistance ng.4 Further d 1886 for the he direction of tant, mapping ke Traverse to wer shore lines erminations of part of these

ited States and to the examisake Agassiz ssisted by Mr. led exploration iles north from reached being

an Naturalist, vol. ited States Army,f bited in the valley Chief of Engine junction of the 0 ef of Engineers, E 3. (General Warm

ience, vol. xxxii, . and Feb., 1884; at Minnesota, for 15 lso explained in li ience Monthly, J

the Geological Sur eport, for 1879, p eport, vols. i andi hes and Deltas of

Shoal Lake, between Lakes Winnipeg and Manitoba, and Orange Ridge post-office, near the southeast end of Riding Mountain. The wooded character of the country farther north makes continuous levelling and tracing the beaches of this lake impracticable; and the same condition limited my examination on the east to a narrow belt adjoining the Red River. The western border of this portion of Lake Agassiz is formed by the Pembina Mountain, the Tiger Hills, the Brandon Hills, and Riding Mountain; and the mouth of the Assiniboine was at Brandon during the highest stage of the lake. In this direction my observations were extended west of the shore line of Lake Agassiz to include the vicinity of the Assiniboine and the Canadian Pacific Railway to Griswold, the course of the Souris River below Plum Creek, Lang's Valley, a glacial water-course extending from the Elbow of the Souris southeast to Pelican Lake and the Pembina River, and the lower course of that river, by which a large delta was deposited in the west margin of Lake Agassiz a few miles south of the international boundary. The breadth of the country thus traversed from east to west is about a hundred and fifty miles.

The upper or Herman beach of Lake Agassiz was traced and its height determined in Minnesota by continuous levelling from Lake Traverse east to Herman and thence north to Maple Lake, twenty miles east-southeast of Crookston, a total distance of about 175 miles, including an extent of 140 miles from south to north. Through North Dakota this shore was thus followed continuously along the west side of the Red River Valley about 250 miles, extending northwesterly from Lake Traverse to the vicinity of Wyndmere, Milnor, and Sheldon, and thence in a nearly direct course slightly west of north to the international boundary. Profiles of the numerous railway lines crossing this district supplied reliable elevations above the sea level at their stations; and in many instances they also show distinctly their intersections of the beaches of this lake. These elevations were taken as the data and reference points of my levelling, which was proved throughout its entire extent to be accurate within close approximation by its agreement with the railway surveys, the comparisons being made at intervals varying from twenty to forty or fifty miles apart. The same methods were employed in this survey in Manitoba, where the profiles of the Canadian Pacific Railway and its branches and of the Manitoba Northwestern Railway, kindly supplied for my examination by the agineers of these roads, were similarly the basis of my determinations of the elevations of the beaches. All these heights, as stated in this eport and in the annexed notes of railway profiles, are referred to the ea level at mean tide; and the close agreements of several independent elevations to urveys from the sea to this district and of the profiles of the many the sea level.

intersecting lines of railway in Minnesota, South and North Dakota and Manitoba, give complete assurance that these heights are not only consistent together but also absolutely true within limits of error probably nowhere exceeding five feet. Such exact determinations of the elevations of the beaches of this lake seem very important because these deposits which were formed along the level shores of the lake in its successive stages are found at the present time to have a gradual ascent from south to north, amounting to about a foot per mile in the highest and oldest beach and gradually diminishing to a quarter or even an eighth part of this amount in the lowest and latest of the beaches. The general topographic features of the region traversed the character of the drift deposits, its underlying geologic formations, and numerous records of the sections passed through by wells, were also noted.

Plan of this report.

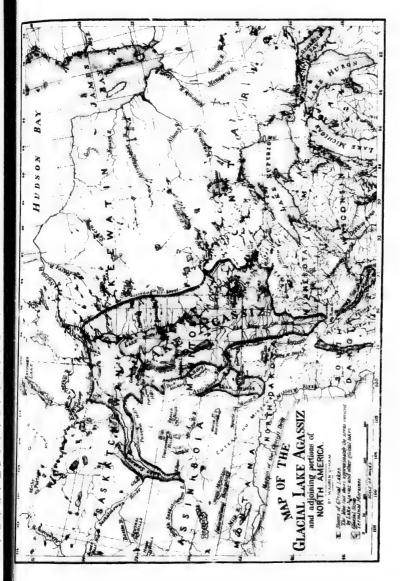
In this report are successively presented a brief description of the topography of the basin of Lake Agassiz, an account of the drift formations in Manitoba, and the history of this glacial lake in its relationship to the recession of the ice-sheet as shown by terminal moraines. The beaches and delta deposits of Lake Agassiz observed in Manitoba are described in detail, including their changes of levels from the time of the highest and earliest to that of the lowest and latest beaches. Next follow notes of wells, and remarks on the soil the agricultural capabilities of the district, and its economic geology. Finally, in Appendices I and II the courses of glacial stria in and about the area of Lake Agassiz, and tables of altitudes in Manitola, Assiniboia and Alberta, are given.

A map showing the whole extent of Lake Agassiz and for comparison with it the upper great lakes that outflow by the Saint Lawrence, and another map showing the beaches of this lake in Manitoba and its deltas brought in by the Assiniboine and Pembina Rivers, accompany Accompanying this report. The courses of glacial strike and the terminal moraines of the ice-sheet are noted on each. It should be remarked, however, respecting the first of these maps, that the northern and northeaster. boundaries of this glacial lake probably can never be exactly determined, and must be laid down in any attempt of this kind, by estimation; for they were formed by the receding ice-sheet instead of a land surface on which beaches would be discoverable. During the formation of its highest continuous and well marked beach, this lake extended north in Minnesota at least to Maple Lake, and in Manitoba to Thornhill. The continued recession of the ice-sheet during the time : formation of the sixteen beaches made at lower levels while the lake outflowed southward probably caused it to attain nearly the area shown of this map before it began to be discharged into Hudson Bay. Afterward,

North Dakota
are not only
of error probnations of the
rtant because
of the lake in
ave a gradual
er mile in the
a quarter or
latest of the
ion traversed,
ic formations,
by wells, were

ription of the tof the drift al lake in its a lake in its a by terminal assiz observed anges of levels he lowest and ks on the soil, comic geology. I strike in and s in Manitola,

or comparison Lawrence, and nitoba and its s, accompany inal moraines ked, however, l northeastern exactly deternd, by estimatead of a land the formation lake extended toba to Thorn the time : le the lake out area shown on y. Afterward,



eleven beaches w various stages, in present represen passed during a waning ice-sheet Nelson River. T by water at any

extent on the nor its earlier area wh

to Hudson Bay. TOPOGRA The area that w

center of the Nor from 45° 30′ to 55° and to 106° on the from south to nor dred miles, or abo and deepest portio he Red River Va hest stage it Lake to the Pemb lake Nipigon, an illy plateau, which Lake Agassiz and ion in the highlar he east and nor ames and Hudso ase of the great rem south to nort nd Duck Mountai nd on the north orth Saskatchew nd covered the up he receding ice-s nger ice-dam**me**d Measured on th

According to measur marteristics of the No Science, III, vol. xxxii

gassiz is about 1 I the five great la m. 22,450; Hur ntario, 7,240; an eleven beaches were formed while the lake stood near y stationary at visions stages, interrupting the further descent of its surface to its present representative, Lake Winnipeg, its northward outflow having passed during a considerable time along the southern border of the waning ice-sheet before it was melted from the present course of the Nelson River. The lacustrine area therefore was not wholly covered by water at any one time; for when the lake reached its maximum extent on the north and northeast, it had receded below that portion of is earlier area which lies above the beaches marking its stages tributary to Hudson Bay.

TOPOGRAPHY OF THE BASIN OF LAKE AGASSIZ.

The area that was covered by Lake Agassiz occupies the geographic center of the North American continent. Its extent is approximately Area of Lake from 45° 30′ to 55° of north latitude, and from 92° 30′ to 100° at Brandon, and to 106° on the Saskatchewan, of west longitude. It thus measures from south to north, and likewise from east to west, nearly seven huntred miles, or about twice the length of Lake Superior. The central and deepest portion of Lake Agassiz covered the broad, flat expanse of he Red River Valley and of the lake region farther north; and in its ighest stage it reached on the international boundary from Rainy take to the Pembina Mountain. It was separated from Lake Superior, take Nipigon, and James Bay by a moderately undulating or in part jily plateau, which rises 300 to 500 feet above the highest shore of lake Agassiz and holds nearly this elevation southward to its terminaion in the highlands bordering Lake Superior, but from which toward he east and northeast a gradual slope descends to the sea level of ames and Hudson Bays. On the west this glacial lake washed the ase of the great range of highlands named in its successive portions rem south to north the Coteau des Prairies, Pembina Mountain, Riding and Duck Mountains, and the Porcupine Mountain, and Pasquia Hills: nd on the northwest it extended beyond the fork of the South and orth Saskatchewan. Northward it reached beyond Lake Winnipeg ad covered the upper part of the course of the Nelson. When finally he receding ice-sheet gave place for this river, the glacial lake, no ager ice-dammed, was reduced to Lake Winnipeg.

Measured on the accompanying map, the probable area of Lake gassiz is about 110,000 square miles. It thus exceeded the total area comparison with the areas the five great lakes, namely, Superior, 31,200 square miles; Michi-Laurentian nn. 22,450; Huron, with Georgian Bay, 23,800; Erie, 9,960; and lakes and the mario, 7,240; amounting together to 94,650 square miles. The Manitoba.

beerding to measurements on the U. S. Lake Survey charts, as stated in "Physical referristics of the Northern and Northwestern Lakes," by L. Y. Schermerhorn, Am. Jour. nence, HI, vol. xxxiii, p. 279, April, 1887.

areas of the three great lakes of Manitoba, remaining where shallow depressions prevented the complete drainage of Lake Agassiz, are approximately as follows: Lake Winnipeg, 8,500 square miles; and Lakes Manitoba and Winnipegosis, each 2,000 square miles.

Depth of Lake Agassiz. At the time of the formation of its highest beach the depth of Lake Agassiz above Fargo and Moorhead was nearly 200 feet; above Grand Forks and Crookston, a little more than 300 feet; above Pembina, Saint Vincent, and Emerson, on the international boundary, about 450 feet; and above Lakes Manitoba and Winnipeg, respectively about 500 and 600 feet. The northward ascent of the beaches of this glacial lake a compared with the level of the present time, and its successive stages during its fall to Lake Winnipeg, will be considered in a later part of this report.

Shore Lines, Deltas, and Dunes.

Beach ridges.

Eroded shores.

Viewed in their relation to the general topography, the shore lines of Lake Agassiz are inconspicuous, though they are very distinctly traceable. They are usually marked by a deposit of beach gravel and sand, forming a continuous, smoothly rounded ridge, such as is found along the shores of the ocean or of our great lakes wherever the land sinks in a gently descending slope beneath the water-level. The beaches of Lake Agassiz commonly rise three to ten feet above the adjoining land on the side that was away from the lake, and ten to twenty feet above the adjoining land on the side where the lake lay. In bready these beach ridges vary from ten to twenty-tive or thirty rods. In some places they have been cut through and carried away by streams and occasionally they are interrupted for a quarter or a half of a mile or even two or three miles, where the outline of the lake shore and the direction of the shore currents prevented such accumulation.

Another type of shore lines is developed where the lake has forme a terrace in the till, with no definite beach deposit, the work of the waves having been to erode and carry away rather than to accumulate. The height of these steep, wave-cut slopes varies from ten to thirty feet, which is indeed a very slight elevation in comparison with the cliffs of till of similar origin on some parts of the shores of Lake Michigan and others of the Laurentain lakes. No portions of the beach ridges nor of these low eroded escarpments, marking the margin of Lake Agassiz, are noteworthy objects in the view from points so far away as two or three miles; but nearer at hand they appear sufficiently impressive, when the mind reverts to the receding ice-sheet and this great glacial lake by which they were made.

Delta deposits of sand and gravel, so extensive as to be important features in the topography, were formed in the edge of Lake Agasa

by several of its tieast side of the lal
west side by the
Pembina formed a
and has a maximu
tain," which rises
few miles south
escarpment about
Valley at its base
the eroded front
brought into Lake
from northwest to
miles. But the la
Manitoba, which
Portage la Prairi

miles north to Gla

miles, and its der

Extensive tracts

about 200 feet.

and Assiniboine Is drifting sand hill hundred feet. T aspect, being parr places wholly dest brifted by the wir graphy of the Re agriculture is also ing prairie, but the intervening probably soon after had spread over to than now, and his stantly undergoin

East from the f and in part rollin eastern Manitoba is mapped approx boundary, where the country adjoi where shallow Agassiz, are re miles; and les. lepth of Lake above Grand

Pembina, Saint bout 450 feet: about 500 and glacial lake a cessive stages a later part of

the shore lines ery distinctly ich gravel and h as is found rever the land

The beaches the adjoining to twenty feet In breadt irty rods. in y by streams. half of a mile shore and the

ion. ke has formel e work of the to accumulate ten to thirty ison with the ores of Lake is of the beach he margin o points so far ippear suffici-

be important Lake Agassi

ice-sheet and

by several of its tributary streams. Such deltas were brought into the east side of the lake by the Buffalo and Sand Hill Rivers; and into the west side by the Sheyenne, Pembina, and Assiniboine Rivers. The Deltas-Pembina formed a delta that reaches twelve miles from north to south and has a maximum width of seven miles. The "First Pembina Mountain," which rises very conspicuously near Walhalla, North Dakota, a few miles south of the international boundary, as a steep wooded escarpment about 175 feet above the flat prairie of the Red River Valley at its base, with its crest 1,150 to 1,200 feet above the sea, is the eroded front of this Pembina delta. The sand and gravel beds brought into Lake Agassiz by the Sheyenne River reach fifty miles from northwest to southeast, and their maximum width is nearly thirty miles. But the largest of all these deltas is that of the Assiniboine in Manitoba, which extends from Brandon seventy-five miles east to Portage la Prairie, and from Treherne, Glenboro and Milford forty miles north to Gladstone and Neepawa. Its area is fully 2,000 square miles, and its depth probably averages 50 feet, with a maximum of about 200 feet.

Extensive tracts of the deltas formed by the Sand Hill, Sheyenne, and Assiniboine Rivers have been heaped up by the wind in dunes, or drifting sand hills, which vary in height from twenty-five to one hundred feet. Their extremely uneven contour, and their singular aspect, being partly covered by small trees and bushes but in many places wholly destitute of vegetation where they are now gullied and lrifted by the wind, make these hills a unique element in the topography of the Red River basin. The worthlessness of the dunes for Dunes. agriculture is also in marked contrast with the fertility of the surrounding prairie, but they frequently include patches of good pasturage in the intervening hollows. The time of formation of these dunes was probably soon after the withdrawal of Lake Agassiz, before vegetation had spread over the surface. The winds could then erode more rapidly than now, and heaped up these hills of sand in nearly their present size and height; but it is evident also that their forms have been constantly undergoing slight changes since that time.

Country adjoining Lake Agassiz.

East from the flat prairie of the Red River Valley is the undulating and in part rolling and hilly wooded region of northern Minnesota and eastern Manitoba. Through this district the outline of Lake Agassiz is mapped approximately. It extends farthest east on the international boundary, where it reaches beyond Rainy Lake. The general level of Wooded region the country adjoining Rainy Lake and the Lake of the Woods is 50 to Manitoba.

150 feet below the highest stage of Lake Agassiz; but the northern and eastern part of this district may have been still covered by the waning ice-sheet when the lake stood at that height. On account of the impracticability of tracing the shores of Lake Agassiz through this wooded and uninhabited region, the northeastern limits of this glacial lake, where the shore in its successive stages passed from the land surface to the barrier of the receding ice-sheet, remain undetermined.

The country north and northeast of Lake Winnipeg presents no considerable elevations, but is mainly a broad, nearly flat expanse, similar to the Red River Valley and the lake district of Manitoba, slowly declining to the sea level. Dr. Robert Bell writes of it as follows:-"The region through which the upper two thirds of the Nelson River flows may be described as a tolerably even Laurentian plain, sloping towards the sea at the rate of about two feet in the mile. The river, for the first hundred miles from Great Playgreen Lake, does not flow in a valley, but spreads itself by many channels over a considerable breadth of country. This tendency to give off 'stray' channels is characteristic of numerous rivers throughout the northern and comparatively level Laurentian regions, but it is perhaps more strongly marked in the Nelson than in any other. In the above section of this stream the straggling channels are of all sizes, from mere brooks up to large rivers. . . . The general aspect of the country is even, or slightly undulating, the highest points seldom rising more than thirty or forty feet above the general level." The country adjoining the lower part of this river, according to the same explorer, has a similar contour only moderately uneven; but the channel of the river, excepting in the ten miles next to its mouth, is deeply eroded. Its enclosing bluffs vary in height from one hundred to two hundred feet between Broad Rapid, where the river is approximately 125 feet above the sea, and Gillam's or Lower Seal Island, which is at the head of the tide, about twenty miles from Hudson Bay.1

Along the west side of the basin of the Minnesota River, of the Rel River Valley, and of Lakes Manitoba and Winnipegosis, the surface rises from two or three hundred to one thousand feet above their slightly undulating or quite flat belt of lowland. No other feature in the contour of the Northwestern States and adjoining British territory is more noteworthy, extended and prominent, than this, excepting perhaps the ascent along the similar and parallel Coteau du Missouri. The latter, however, lacks the accompaniment of such a continuous broad depression beside it. This wide valley, occupied by Lake Winnipeg, Manitoba and others, and by the Red and Minnesota River.

Plain sloping from Lake Winnipeg to Hudson Bay, described by Dr. Bell.

Ascent westward from Lake Agassiz. varying in elever of the slowly as westward to a last the foot of Most of this electric fire feet per mit River to the Romately from so again in the Courlace rises most and continuing a glacial lake whice

Rivers.
The southern

high Coteau des of South Dakota, des Prairies, wes seventy-five mile spicuous, or in sofems the oppose Farther north the Pembina Mountar Iouressive parts of the grown North I begosis to the Samed are divide

Pembina Mount or a distance of a f the internation art of T. 158, R. outh and Middle but six miles easighland turns to me Tiger Hills. 100 feet high, ex a few degrees ries from a half plateau, having

with slow ascer undary averages

¹ Geological Survey, Reports of Progress for 1877 to 1879.

the northern overed by the On account of z through this of this glacial from the land undetermined esents no conpanse. similar nitoba, slowly t as follows:e Nelson River

plain, sloping The river, for s not flow in a lerable breadth s characteristic paratively level marked in the his stream the ks up to large von, or slightly thirty or forty the lower part imilar contour er, excepting in enclosing bluffs between Broad ove the sea, and the tide, about

iver, of the Red osis, the surface eet above their other feature in British territory this, excepting eau du Missouri. h a continuous pied by Lake innesota Rivers

varying in elevation from 710 to 1,100 feet above the sea, is the base of the slowly ascending expanse of the great plains which rise thence westward to a height somewhat exceeding 4.000 feet above sea level at the foot of the Rocky Mountains on the international boundary. Most of this elevation is attained by a gradual slope, averaging four or fire feet per mile throughout the distance of 730 miles from the Red River to the Rocky Mountains; but at two lines, extending approximately from south to north, first on the west side of this valley, and again in the Coteau du Missouri, 100 to 200 miles farther west, the surface rises more rapidly several hundred feet within a few miles by a terrace-like ascent. The first was the western shore of Lake Agassiz, and continuing south and southeast held the same relation to an earlier glacial lake which occupied the basin of the Minnesota and Blue Earth Rivers.

The southern portion of this line of elevation is the massive and high Coteau des Prairies of southwestern Minnesota and the east part of South Dakota. Its lower continuation from the Head of the Coteau e. Prairies, west of Lake Traverse, for the next one hundred and Coteau des eventy-five miles northward, bears no name, and is scarcely more con-highland picuous, or in some parts even less so, than the moderate ascent that continuing thence north. orths the opposite border of the Red River Valley in Minnesota. Earther north this line of higher land rises abruptly 300 to 500 feet in Pembina Mountain, and from 500 to 1,000 feet in Riding and Duck Countains and the Porcupine and Pasquia Hills. All of these are accessive parts of a very remarkable terrace-like escarpment, stretchng from North Daket, by the west side of Lakes Ma itoba and Winnierosis to the Saskatchewan River. Its portions thus differently amed are divided by deep and broad valleys eroded by intersecting

Pembina Mountain is a distinct and conspicuous topographic feature radistance of about seventy-five miles, of which two thirds lie north the international boundary. Its southern end is in the southwest rt of T. 158, R. 56, in Walsh county, North Dakota, between the outh and Middle branches of Park River; and its northern end is Pembina out six miles east-southeast from Treherne, where the course of this ghland turns to the west and its more uneven continuation takes the me Tiger Hills. It is a prominent, wooded escarpment, mostly 300 400 feet high, extending in a very direct course from south to north a few degrees west of north. The width occupied by its slope ries from a half of a mile to two or three miles, and from its crest plateau, having a moderately rolling surface, stretches nearly level with slow ascent westward. Its crest north of the international undary averages about 400 feet above its base, or 1,400 feet above

LPHAN.

2,300 to 2,700

Manitoba; une

feet above the

lakes on the ea

The reader is

district of Ridi

reports of this

of the shore lin

across the basir

continued in th

twenty-tive mile

plateau, similar

acclivity on the

side another gar

and Overflowing

Next are the

bina, Riding an

about a hundred

Pasquia Hills ext

they formed the

Agassiz, lying ab

and parallel with

River. They are

croded country w

plateau of North

holding the same

Tiger Hills sustai

The glacial La

Beyond Duck

the sea; but within a few miles farther west the rolling surface of the highland rises 100 to 200 feet higher.

Northwestward from Treherne the plateau of which Pembina Mount tain forms the eastern edge, is interrupted across a distance of sixty. five miles, to Riding Mountain. This broad depression is occupied by the Assiniboine and its tributaries, and by small streams on the north east which send their waters to Lake Manitoba. The plateau, indeed, loses its regularity of surface upon all the country farther north and west, because it has been eroded to the depth of several hundred feet on the greater part of the basin of the Assiniboine.

The border of the plateau south of this river, reaching from close south of Treherne westerly fifty miles to the Elbow of the Souris River is called the Tiger Hills.1 It is irregularly sculptured in steen rounded, massive hills, and is overspread by drift deposits consisting partly of morainic accumulations. For a distance of forty miles west from the Pembina Mountain this belt occupies a width of five to eight miles, upon which the surface falls from south to north 300 to 400 feet. The country on the south has an average elevation nearly the same as the summits of the hills, which yet rise very prominently seen from the lower region on the north. The western part of the Tiger Hills, extending ten or twelve miles east and an equal distance west from the gorge that is cut through the range by the Souris, rise considerably above the adjoining nearly flat surface on each side. The foot of the belt of hills there is 100 to 150 feet lower on the north than on the south; and the Souris flows through it in a gorge 350 feet deep From this vicinity Hind applied the name Blue Hills of the Sourist

North of the Assiniboine the eastern outline of the continuation this plateau is preserved in the prominent elevations of Riding and Duck Mountains, two remarkable wooded highlands, much alike is their general features and extent. The steep eastern escarpment each is about fifty miles long, that of Riding Mountain trending in southeast to northwest, and that of Duck Mountain having a course few degrees west of north. These elevations rise above the count: adjoining the Assiniboine by a somewhat gradual slope, but they an abruptly cut off on their northeast side by a precipitous descent. The takes place on a line approximately parallel with Lakes Manitobam Mr. J. B. Tyrrell's measurements, are respectively about 2,000 at

this belt, but that name is not used by the people of the district.

Winnipegosis, the former of these lakes being about forty miles east Riding Mountain, while the south end of the latter is twenty-five mile east of Duck Mountain. The crests of these highlands, according

Assiniboine Valley.

Tiger Hills.

Riding and

Duck Mountains.

Existin

erosion and lower racessively lowe departure of the great lakes of Mar. Manitoba, and Wi e mparatively sm: lows near its mou tributary to it, an katchewan River, Lake Winnipeg e theoutheast to

¹ From the aboriginal name, which doubtless refers to the cougar or American Panther life

surface of the

mbina Moun. ance of sixty. is occupied by on the north. latenu, indeed. her north and

d hundred feet ing from close e Souris River cured in stee sits consisting orty miles wes of five to eigh orth 300 to 400 tion nearly the prominently to ern part of the equal distance

the Souris, riseach side. The the north that ge 350 feet dee; of the Souris e district. continuation: s of Riding and

much alike n escarpment n trending from aving a course ove the country pe, but they a us descent. T. kes Manitobaan rty miles east wenty-five mile ds, according

about 2,000 a

2300 to 2,700 feet above the sen, the latter being the highest land in Manitoba; and the bases of their escarpments are about 1,200 to 1,500 feet above the sea, being four hundred to seven hundred feet above the lakes on the east, whose height slightly exceeds 800 feet.

The reader is referred to Mr. Tyrrell's maps and descriptions of the district of Riding and Duck Mountains, to be published in the annual Maps and reports of this Survey, for details of its topography and geology and Tyrrell. of the shore lines of Lake Agassiz north of the limit of my exploration.

Beyond Duck Mountain, after an interruption of about thirty miles across the basins of Swan and Woody Rivers, this line of highlands is continued in the Porcupine Mountain or Hills, which reach about Porcupine eventy-five miles from south to north. These form a somewhat broken plateau, similar with the preceding in its general features of steep activity on the east and gentle descent westward. On their north side another gap about twenty miles wide is occupied by the Red Deer and Overflowing Rivers.

Next are the Pasquia Hills, whose eastern end is in line with Pemlina, Riding and Duck Mountains, and the Porcupine Hills, being about a hundred miles west from the mouth of the Saskatchewan. The Pasquia Hills extend thence a hundred and fifty miles westward, where they formed the southern shore of the northwestern arm of Lake Pasquia Hills. Agassiz, lying about twenty-five miles south of the Saskatchewan River and parallel with it, to the Birch Hills and the South Saskatchewan Ever. They are the northern escarpment limiting the irregularly goded country which is here considered as an extension of the great plateau of North Dakota and southern Manitoba and Assiniboia, thus biding the same relation to the valley of the Saskatchewan that the Ther Hills sustain to the Assiniboine Valley.

Existing Lakes within the area of Lake Agassiz.

The glacial Lake Agassiz was gradually reduced in size, first by the erosion and lowering of its southward outlet, and afterward by finding successively lower outlets to the northeast, until with the complete reparture of the ice-sheet it sank to its present representatives, the great lakes of Manitoba. These are three in number, Lakes Winnipeg, The Manitoba, and Winnipegosis. With them are associated several others, comparatively small, as Cedar Lake, through which the Saskatchewan lows near its mouth, Lake Dauphin, south of Lake Winnipegosis and libutary to it, and Lake Saint Martin on the Fairford or Little Saskatchewan River, the outlet of Lakes Manitoba and Winnipegosis.

Lake Winnipeg is two hundred and fifty miles long, trending from th-southeast to north-northwest. The maximum width of its southern

Its area is approximately 8,500 square miles, being intermediate in extent between Lakes Ontario and ' .. Eighty-five miles from its LakeWinnipeg, south end, Lake Winnipeg is reduce strait two to four miles with which extends northwesterly two miles, terminating at the cape called Dog's Head. The narrowest part of the strait, scarcely exceed. ing a mile in width, is at this cape. Here the strait opens into the northern and main portion of the lake, which includes five-sixths of its area. The elevation of Lake Winnipeg, determined by the surveys to the Canadian Pacific Railway, is 710 feet above the sea. Its depth according to Mr. J. Hoyes Panton, nowhere exceeds sixty-five feet "The shallowness of this comparatively large body of water," as Mr Panton writes, "accounts for its treacherous nature and explains how on many occasions it has proved a disastrous water-way to the freight ing boats of by-gone days. As you sit upon the deek of the steam; threading its way among the islands, you are surprised at the tortuou. course made, when water seems on every side and no shore near, 8 shallow is the lake that many places miles from land are not covered with more than six or seven feet of water. It is only safe to experienced captains, thoroughly acquainted with the concealed channel that afford a safe course at a distance from the shore." 1 On account this slight depth, the mud brought in by the Red River is held in sas pension, being almost constantly stirred up from the bottom by the waves of the lake, throughout its southern half; but in the broad northern half of its length, beyond Beren's River and Island, the water

> Lake Manitoba, from which comes the name of the province Manitoba, lies about forty miles west of the south half of Lake Will peg; and Lake Winnipegosis, separated only about two miles from the north end of Lake Manitoba, lies mostly forty to fifty miles west of the north half of Lake Winnipeg, but its most northeast part is only twenty miles southwest from that lake. The length of each of these lake

> is comparatively clear.2 Low land borders this lake along nearly

whole extent, and the highest points on the shore or visible from

rarely attain an elevation of fifty feet,

Lakes Manitoba and Winnipegosis.

> 1 "Notes on the Geology of some islands in Lake Winnipeg." Transactions of the Historical Scientific Society of Manitoba, Jan. 28, 1886

CHAN.

measured in trending in p an area of nea to their size, t of Lake Mani its middle, it two miles lon: nearly interse according to le being thus alm The country ! Lake Dauphin mately level, b per mile. The miles. Its nor following this c moreover, are v sion of bays, car Lake and River teet above the la Railway, or 828

Rainy Lake a ary, are bodies c part of the area fifty miles, tren average width is approximately. bays and narrow is about 1,117 fee by Dr. A. C. Law The Lake of the

ing a large penin on the north and ly narrow channe arface, excepting adjoins Minneso west, its maximun mately; and its ar nined by the Cana es: and the maxis lake, is stated by

^{2 &}quot; Lake Winnipeg receives its name from the muddy or sallow appearance of its watersignifies muddy, and Nepe water, in Chippewa."-Keating's Narrative of Long's Expedi vol. ii, p. 77.

Meaning the "Narrows or Strait of the Manitou or Great Spirit," as I am informed by from Prof. George Bryce and Mr. J. B. Tyrrell. This name was originally pronounced by a inhabitants, nearly as by the Indians, with accents on the initial and final syllables; but in the past ten years or more its almost universal pronunciation in English has been with only accent, which is laid on the next to the last syllable.

⁴ Meaning "Little Winnipeg."-Hind's Narative of the Canadian Exploring Expel vol. ii, p. 42.

mixty miles ermediace is illes from its r miles wide at the cape reely exceedpens into the e-sixths of its he surveys to n. It- depth ixty-five feet vater." as Ma explains how to the freight of the steamer at the tortuon hore near. 8 are not covered safe to experi-

cealed channels On account c er is held in sa bottom by the ut in the broa sland, the wate along nearly a or visible from

the province of Lake Winns o miles from t miles west of the rt is only twenty h of these lake us of the Historical

ance of its water of Long's Expedit am informed by is y pronounced by a

I syllables; but dur has been with only Exploring Expedi

measured in a straight line, is about a hundred and twenty miles. trending in parallelism with Lake Winnipeg; and each of them covers an area of nearly 2,000 square miles. Both are shallow in proportion to their size, and are surrounded by low shores. The maximum width of Lake Manitoba, about twenty-eight miles, is at its south end. Near its middle, it is narrowed to a strait about half a mile wide and two miles long. Its northern part is of quite irregular form, and is nearly intersected from the north by a long peninsula. This lake, according to levelling by Mr. H. S. Treherne, is 809 feet above the sea, being thus almost exactly a hundred feet higher than Lake Winnipeg. The country between these lakes and from Lake Manitoba west to Lake Dauphin and to Riding and Duck Mountains is low and approximately level, but has a general westward ascent, averaging a few feet ner mile. The width of Lake Winnipegosis varies from five to fifteen miles. Its northern portion is bent to the west, so that its length. following this curve, is nearly a hundred and fifty miles. Its outlines. moreover, are very irregular, presenting a constantly varying succession of bays, capes, and islands. This lake outflows by the Water Hen Lake and River to Lake Manitoba, and has n elevation of nineteen feet above the latter, as determined by surveys for the Canadian Pacific Railway, or 828 feet above the sea.

Rainy Lake and the Lake of the Woods, on the international boundary, are bodies of water of considerable size, lying within the eastern part of the area of Lake Agassiz. The length of Rainy Lake is nearly Rainy Lake. fifty miles, trending from east-southeast to west-northwest, and its average width is about five miles, giving it an area of 250 square miles. approximately. It is much diversified by projecting points, numerous bays and narrow arms, and plentiful islands. Its height above the sea is about 1.117 feet; and its maximum depth, according to soundings by Dr. A. C. Lawson, is a hundred and ten feet.

The Lake of the Woods has a very irregular form, nearly surrounding a large peninsula in its northern part, and including many bays on the north and east, some of them connected with the main lake only by narrow channels. A multitude of islands, large and small, dot its surface, excepting in its southwest part, called Sand Hill Lake, where adjoins Minnesota. Measured from north to south or from east to Lake of the west, its maximum extent in either direction is sixty miles, approxinately; and its area is about 1,500 square miles. Its elevation, deternined by the Canadian Pacific Railway survey, is 1,060 feet above the es; and the maximum depth of its northern part, called Clear Water ake, is stated by Dr. Dawson to be eighty-four feet.

Rivers tributary to Lake Agassiz and draining its area.

Present drainage of the area of Lake Agassiz.

The area of Lake Agassiz is drained to Lake Winnipeg, chiefly by the Winnipeg, Red, and Little Saskatchewan or Fairford Rivers. On the northwest this glacial lake also included the region crossed by the lower part of the Saskatchewan. Flowing out from Lake Winnipeg, the united waters of all these river systems are carried by the Nelson to Hudson Bay.

It seems probable that the recession of the ice-sheet uncovered the entire course of the Rainy and Winnipeg Rivers before Lake Agassiz had fallen below the level of Rainy Lake. These are upper and lower portions of the main trunk of the same river system. East of Rainv Lake a large tract tributary to it reaches nearly a hundred miles on the international boundary, including almost countless lakes and small streams. The Rainy River, about eighty miles long, connecting Rains Lake and the Lake of the Woods, is a broad and majestic, deep stream with an average width of a sixth of a mile, flowing in general in a somewhat direct west-northwest course. At the mouth of Rainy Lake it has rapids that fall about three feet. Its principal falls are at Fort Francis, a little more than two miles from Rainy Lake, where it descends twenty-three feet in about a tenth of a mile. Maniton Rapids, about thirty-five miles from Rainy Lake, are a short descent of about two feet, with outeropping rock in the channel and banks. Six miles below these is the Long Sault, a mile in length, estimated

by Major Long to have "an aggregate descent of about ten feet,

Excepting these rapids, Rainy River has an average descent of only

about three inches per mile, giving to the ordinary low stage a

water a very gentle current. It is navigable for large steamboats from

the Lake of the Woods to the foot of the Long Sault; and thence to

Rainy Lake it is navigated by a tug or propeller, towing Mackings

boats. The banks of the river are only ten to twenty feet high, and

are fertile and heavily wooded, having commonly a clayey soil.

Winnipeg River, the outlet of the Lake of the Woods, has a length of about a hundred and sixty miles, flowing in a winding course to the northwest. Its total descent is 350 feet, four-fifths of this being in the many falls and rapids which occur along nearly its entire extent. These falls are divided by portions with only a strong or gentle current, or by lake-like expansions of the river where no current is pecceptible. On each side the country rises to a moderate elevation in low hills and ridges, with frequent outcrops of the bed-rocks. The highest land crossed by the Canadian Pacific Railway south of the Winnipeg River, from eighteen to twenty-eight miles west of Ra Portage, is about 200 feet above the Lake of the Woods and about 35

Rainy River.

Winnipeg River. эндм.

feet above La Lake Agassiz, Lake, is a larg important afflu siderable area River is very c

of Lake Winnip The Red Riv Red River of L above the sen, t about sixty mile Many Point, R Lakes, to Otter Tail River, In The contour of t andulating or fl called the Red 1 and the prevailir as Otter Tail Riv miles west of O feet, or about five Because of the n its volume along by either heavy r. at Breckenridge measured in a di the Red River, n south, west, and nowhere diverging miles. Its descen its source to its McCauleyville and ridge, it is navigat the Goose Rapids, of Goose River as the channel is obs low stages of wate varies from six to length of the steam is commonly twent lighest stages inc

hirty-two feet at M

lity feet at Belmon

, chiefly by ivers. On used by the Winnipeg. the Nelson

covered the

anke Agassiz er and lower ast of Rainy red miles on ces and small ecting Rainy deep stream general in a f Rainy Lake ls are at Fort ke, where it ile. Manitou ort descent of d banks. Six gth, estimated out ten feet. escent of only low stage eamboats from and chence to ing Mackinaw

feet high, and vey soil. s, has a length course to the is being in the entire extent current is pelte elevation is y south of the west of Ra

feet above Lake Winnipeg, rising thus nearly to the highest level of Lake Agassiz. English River, which flows through Lac Seul or Lonely Lake, is a large tributary of the Winnipeg from the east. The only important affluent from the south is the Whitemouth, draining a considerable area west of the Lake of the Woods. The water of Winnipeg River is very clear, and is strongly contrasted with the muddy water of Lake Winnipog with which it mingles at its mouth.

The Red River of the North, so named to distinguish it from the Red River of Louisiana, has its source in a small lake about 1,600 feet above the sea, thirteen miles west of Lake Itasca. It first flows south about sixty miles, measured in a direct line, passing through Elbow, Many Point, Round, Height of Land, Little Pine, Pine, and Rush Lakes, to Otter Tail Lake, this portion being commonly called Otter Tail River. In this distance it descends to 1,315 feet above the sea Red River of The contour of the adjoining country is rolling or hilly northward and andulating or flat southward. Below Otter Tail Lake this stream is ralled the Red River by this report, following the example of Owen and the prevailing popular usage; but it is still occasionally spoken of as Otter Tail River to its junction with the Bois des Sioux, forty-two miles west of Otter Tail Lake. The descent in this distance is 372 feet, or about five feet per mile, following the course of the stream Because of the numerous large lakes on the upper part of its course, its volume along this descent to Breckenridge is not greatly affected by either heavy rains and snow-melting or dry seasons. From its bend at Breckenridge and Wahpeton the Red River flows north 285 miles. measured in a direct line, to Lake Winnipeg. The entire length of the Red River, measured thus in straight lines successively to the Length, and south, west, and north, is about 390 miles; but in its meanderings, descent. nowhere diverging far from these lines, it flows nearly seven hundred miles. Its descent below Breckenridge is 233 feet, and in total from its source to its mouth approximately 900 feet. All the way below Metauleyville and Fort Abercrombie, fifteen miles north of Breckenridge, it is navigated by steamboats, barges, and flat-boats; but along Navigation, the Goose Rapids, extending about twelve miles next below the mouth of Goose River as measured in the meandering course of the stream, the channel is obstructed by boulders which forbid navigation during low stages of water. The width of this river in the United States varies from six to twenty rods, being in some places less than the length of the steamboats; but north of the international boundary it scommonly twenty rods wide. The range between its lowest and lighest stages increases rapidly north of Breckenridge, becoming hirty-two feet at Moorhead and Fargo, and attaining its maximum of and about 55 afty feet at Belmont. It continues nearly at forty feet from Grand

Forks to the international boundary and to Winnipeg. Fort Garry, sixteen miles north of Winnipeg and about twenty miles from the mouth of the river, it is thirty-five feet; but beyond that point it rapidly diminishes in approaching Lake Winnipeg. Floods rising nearly or quite to the high water line thus noted have been rare, occurring in 1826, 1852, 1860, 1861, and 1882. They are caused in the spring by the melting of unusual supplies of snow and by accompanying heavy rains, and often are increased by gorges of ice. These floods attain a height only a few feet below the level of the adjoining prairie where that is highest, and along the greater part of the distance between Grand Forks and Lower Fort Garry the banks are overflowed and the flat land on each side of the river to a distance of two to four or five miles from it is covered with water one to five feet or more in depth,

Tributaries of Red River.

Sheyenne River.

Excepting the Red Lake River and the Sheyenne, Pembina, and Assiniboine, all the tributaries of the Red River are small, the length of their areas of drainage varying from forty to seventy-five miles. In summer droughts several of them, including the Bois des Sioux, are dried up along the greater part of their course, containing only here and there pools in the deeper hollows of their channels.

Sheyenne River, having its sources near the great southeastern bend of the Seuris River in North Dakota, first flows to the east nearly a hundred miles, passing ten miles south of Devil's Lake; next it flows south about a hundred miles, to where it enters the area of Lake Agassiz; and thence its course is eastward and northward, uniting with the Red River ten miles north of Fargo and Moorhead, The large valley of the upper part of this river, and its extensive delta deposited in Lake Agassiz, are probably attributable to a stream much larger than the present Sheyenne, formed by drainage from the ice sheet when it terminated near Devil's Lake. At that time, also, a glacial lake in the basin of the Souris outflowed southeastward to the Sheyenne and James Rivers.

During a later stage in the recession of the ice-sheet, this glacial lake in the Souris basin was extended west and north of Turtle Mountain and finally found a lower outlet in southern Manitoba. Its outflowing river ran southeasterly from the Elbow of the Souris, eighteen miles southwest of its mouth, to the Pembina River. Pelican Lake eleven miles long from northwest to southeast and about a mile wide occupies a part of the channel of this stream; and a distinct water course of similar width, called Lang's Valley, eroded 110 to 150 fee below the general level, extends eleven miles between this lake and

Lang's Valley.

the Souris. Th the sea and a enclosed by blu Lakes Travers

tHAV.

River Warren Pembina Riv a rather crooke edge of North in a direct line, junction with th First Pembina A Rock Lake and long and from a into this valley drainage from t Pembina runs ir from the northe feet, and thence being 748 feet al

The Assiniboi basin three hund miles long from if the Porcupine hundred miles, t Qu'Appelle and t about a hundred level at the mout Canadian Pacific Souris, about 1,1 junction with the stages of water, Fort Ellice at th caries from ten te

or Cypress Rive

the south side.

The highest flo a considerable dis its lowest stage, the highest portic merged. At this

This name is stated shortened and corr de, L.).-Narrative

¹ Named for James Lang, who was the first immigrant here, coming in 1880.

At Lower twenty miles beyond that peg. Floods d have been y are caused now and by gorges of ice. level of the reater part of erv the banks to a distance

Pembina, and all, the length five miles. In les Sioux, are ing only here

er one to five

theastern bend east nearly a ; next it flows area of Lake hward, uniting oorhead. The xtensive delta a stream much from the icet time, also, a eastward to the

et, this glacial f Turtle Mounitoba. Its out ouris, eighteen Pelican Lake. ut a mile wile distinct water 110 to 150 fee this lake and

the Souris. The highest portion of Lang's Valley is 1,364 feet above the sea and about 100 feet above the Souris at its Elbow, and it is enclosed by bluffs 110 feet high. It is a channel similar to that of Lakes Traverse and Big Stone and Brown's Valley, eroded by the River Warren outflowing from Lake Agassiz.

Pembina River 1 flows from the northern part of Turtle Mountain in s rather crooked easterly course through southern Manitoba and the edge of North Dakota about one hundred and thirty miles, measured in a direct line, to its mouth at Pembina and Saint Vincent. From its innetion with the outlet of Pelican Lake to Walhalla at the base of the First Pembina Mountain, its valley varies from 175 to 450 feet in depth. Rock Lake and Swan Lake on this part of the river, each several miles long and from a half mile to one mile wide, are due to deposits brought into this valley by tributaries after it ceased to be the avenue of drainage from the Souris basin. In crossing the Red River Valley the Pembina runs in a channel only twenty to forty feet deep. Its descent from the northern base of Turtle Mountain to Walhalla is about 700 ject, and thence to its mouth 186 feet, its junction with the Red River being 748 feet above the sea. Long or White Mud River, Clearwater or Cypress River, and Tongue River, are its chief tributaries, all from

The Assiniboine, the largest tributary of the Red River, drains a lasin three hundred miles wide from south to north and four hundred miles long from west to east. From its sources, fifty miles southwest of the Porcupine Hills, the Assiniboine flows south-southeasterly two hundred miles, to a point about fifty miles below the mouth of the Qu'Appelle and forty miles west of Brandon; thence it flows easterly River. about a hundred and fifty miles to its mouth. Its height above sea level at the mouth of the Qu'Appelle is 1,264 feet; at the bridge of the Canadian Pacific Railway near Brandon, 1,161 feet; at the mouth of the Souris, about 1,100 feet; at Portage la Prairie, 842 feet; and at its anction with the Red River in Winnipeg, 724 feet. During its high stages of water, the Assiniboine has been navigated by steamboats to Fort Ellice at the mouth of the Qu'Appelle. Along this portion it varies from ten to twenty-five rods in width.

The highest floods of the Assiniboine at Portage la Prairie and along a considerable distance eastward rise only twelve to fifteen feet above is lowest stage, but they then attain a height only a few feet below overflow from the highest portions of the adjoining country, much of which is sub-the Assimboine merged. At this extreme height, which the river reached and main-Munitoba.

Pembina River.

This name is stated by Keating to be from the Ojibway word "anepeminan, which name has en shortened and corrupted into Pembina," meaning the fruit of the bush cranberry (Viburnum (die, L.) .- Narrative of Long's Expedition, vol. ii, p. 38.

tained from the 3rd to the 15th of May, 1882, the only time of such high water since 1860 or 1861, it overflowed near the former site of the fort of the Hudson's Bay Company two miles southwest of Portage la Prairie, and a portion of its flood passed north in shallow, winding water-courses to Lake Manitoba, making a descent of about forty feet in the distance of fifteen miles between the river and the lake. Near the same time Lake Manitoba also reached its highest stage, about eight feet above its lowest level, rising until it overflowed southward across the east part of T. 13, R. 6, and thence eastward through the southern row of sections in T. 13, R. 5, falling ten feet in fifteen miles to Long Lake, through which old channel of the Assiniboine its waters were discharged into this river twenty miles east of Portage la Prairie.

Qu'Appelle or Calling River and the Souris or Mouse River are the

largest tributaries of the Assiniboine. Each of these streams has an

interesting glacial history, which is recorded in the topographic

Overflow from Lake Manitoba to Long Lake and the Assiniboine.

Qu'Appelle Valley, the outlet of the Saskatchewan glacial lake, features of their valleys and areas of drainage. The Qu'Appelle valley was the outlet of a glacial lake in the basin of the South Saskatchewal. The description, map and sections given by Hind. show that this valley is quite uniformly about one mile wide, and is from 110 to 550 feet below the general level of the region through which it lies, this height being reached by steep bluffs on each side. Its length, from the Elbow of the South Saskatchewan to its junction with the Assinboine is about two hundred and seventy miles, the general course

being a little to the south of east. Of this extent the west end of the valley for about twelve miles is occupied by the River that Turns, and the remainder by the Qu'Appelle, the summit or height of land in this channel at the divide between these rivers being approximately 85 feet above the South Saskatchewan, 440 feet above the mouth of the Qu'Appelle, and 1,700 feet above the sea. The enclosing bluths are composed mainly of glacial drift, with only a few exposures of the underlying Cretaceous rocks. The alluvial bottomland of the Qu'Appelle is generally from a half mile to one mile wide, and through it the river flows in a winding course, here and there passing through long lakes. Like the similar lakes of the Pembina and Minnesota Rivers these owe their existence to the recent deposits of tributaries, and

¹ Compare H. S. Treherne's description of this vicinity, "An ancient outlet of Lake Manith's Ninth Annual Report of the Geological and Natural History Survey of Minnesota (for the year 1890), pp. 388-392.

show that the bed of the glacial river was considerably lower than

that of the present stream. The outflow of the Saskatchewan gladal

lake, fed by the melting ice-fields of an immense area reaching west t

2-14.]

the Rocky Moun er valley, enterin border of Lake A Long or Last north and one or og Appelle and to The elevation of lower than the d sakatchewan to asheet had rece extend to the di brained some low athis lake, fors eati elevation Agassiz since tha Ge of several su 8 katchewan basi even a hundred fe Cappelle, that i derence being pr between the old an Souris River, flo ato North Dakota Latary to the As eve basin, at firs sholly drained av Pembina River. ! mes, but it is only rth Dakota its love the son, and

Little Saskatchever than two hunds equal distance Winnipegosis to the receives several small liver, the outlet of this identity River, the outlet of the thick of the Swan, Received Riding and D. Riding and D.

Report of the Assinibois

² Report of the Assiniboine and Saskatchewan Exploring Expedition, Toronto, 1859, by Heavy Youle Hind.

me of such

er site of the

f Portage la

ow, winding

ut forty feet

lake. Near

stage, about

1 sorthwart

through the fifteen miles

ne it- waters

Portage la

River are the

eams has an

topograpale

prene Vaner

askatelewa...

ow that this

m 110 to 350

h it lies tid

length, from th the Assis

energe college

est end of the

at Turns, and

of land in this

nately 85 les

nouth of the

ng blutt- are

osures of the f the Qu'Ap-

hrough it the

through long

nesota Rivers.

ibutaries, and

ly lower than

hewan glacial:

the Rocky Mountains, took its course east by this trough-like channel or valley, entering the Assiniboine at Fort Ellice and reaching the border of Lake Agassiz at Brandon. Long or Last Mountain Lake, about fifty miles long from south to

with and one or two miles wide, lying north of the upper part of the reAppelle and tributary to it, occupies a similar glacial water-course. Long Lake The elevation of Long Lake is 1,598 feet, being about a hundred feet probably the lawer than the divide in the channel from the Elbow of the South outlet from the Saskatchewan to the Qu'Appelle. It seems probable that when the basin. sheet had receded so far north as to allow the Saskatchewan lake to extend to the district northwest and north of Long Lake, it there brained some lower point of discharge and outflowed along the course of this lake, forsaking its former outlet.1 Owing to the changes in elevation which have taken place in the region of Lake Agassiz since that time, this new outlet, or the earliest and highest one of several successive outlets, across the water-shed between the Seskatchewan basin and Long Lake may now be found fifty or perhaps eren a hundred feet higher than the old channel to the head of the crappelle, that is, 1,750 or 1,800 feet above the sea, the possible rence being probably as much as a foot to each mile of the distance between the old and new outlets.

Souris River, flowing circuitously southwestward from Assiniboia North Dakota and thence northeastward into Manitoba, became batary to the Assiniboine after the waters of the glacial lake in its own basin, at first flowing to the James and Sheyenne, had been Souris River wholly drained away by its outlet through Lang's Valley and the Pembina River. The length of the Souris is nearly four hundred a.es, but it is only five to ten rods wide along its lower portion. In with Dakota its descent is approximately from 1,650 to 1,400 feet love the sea, and thence to its mouth it falls about three hundred

Little Saskatchewan or Fairford River drains an area that extends ere than two hundred miles west from Lake Winnipeg and includes a equal distance in latitude, from the most northern part of Lake Winnipegosis to the south end of Lake Manitoba. The latter lake ereives several small streams at its south end; and the Water Hen Little River, the outlet of Lake Winnipegosis, flows into its north end. Four River. ensiderable streams are tributary to Lake Winnipegosis, namely, the lossy River, the outlet of Lake Dauphin, flowing into its south end, ed the Swan, Red Deer, and Overflowing Rivers at its northwest nd. Riding and Duck Mountains form the southwestern boundary of

ching west t f Lake Manit esota (for the year to, 1859, by Hers

Report of the Assimboine and Saskatchewan Exploring Expedition, 1859, pp. 28 and 35.

this basin; but the Porcupine Hills are entirely enclosed between the Swan and Red Deer Rivers, and the latter drains much of the plateau bordered by the Pasquia Hills.

The lower part of the basin of the Saskatchewan, next to its mouth was latest occupied by the ice-sheet; but that area was relinquished by it, allowing this great river to take its present course, long before Lake Agassiz began to be drained northward. From the most western sources of the Saskatchewan in the Rocky Mountains to its mouth is a distance of more than seven hundred miles; and the maximum width of its basin is about three hundred and fifty miles. Its two branches of nearly equal size, the North and South Saskatchewan Rivers, unite two hundred and thirty miles west of Lake Winnipeg. The elevation of the South Saskatchewan at Medicine Hat, where it is crossed by the Canadian Pacific Railway, is 2,137 feet; at its Elbow, 1,619 feet

approximately; and at its junction with the North Saskatchewan, about

1,200 feet. Cedar and Cross Lakes, through which the Saskatchewan

flows near its mouth, are approximately 114 and 108 feet above Lake

Winnipeg, or 824 and 818 feet above the sea. Hind informs us that

the name Saskatchewan means "the river that runs swiftly;" and he

states that in the Grand Rapids, between Cross Lake and its mouth.

falls forty-three feet in two and a half miles. Its average descent per

mile from Medicine Hat eastward is about two feet. The Saskatchewan

Saskatchewan River.

Grand Rapids.

Navigation.

Adjoining

and both its North and South branches for several hundred miles above their junction vary commonly from a sixth to a third of a mile u. width, and during favorable stages of water are navigable by steam. boats from Cedar Lake to the Rocky Mountain House on the Nor's Saskatchewan, about 3,000 feet above the sea, and beyond the confluence of the Bow and Belly Rivers, which form the South Saskatche wan, fifty miles west of Medicine Hat, at an elevation exceeding 2.2% The chief hindrances to their navigation in low stages and shifting sand-bars, over which they expand in some places to width of a half mile to one mile, being very shallow and divided by low sandy islands. The adjoining country rises within a few miles from these rivers, or at the farthest ten or twenty miles, to an elevation three hundred to six hundred feet or more above them, excepting along the last hundred miles of the Saskatchewan, where it flows through a broad lowland region. There the highest parts of the country are only for to a hundred feet above the river, and its shores are generally low aid in many portions swampy.

Besides the great tributaries of Lake Winnipeg, namely, the Winnipeg, Red, Little Saskatchewan and Saskatchewan Rivers, about a doze

streams varying and twenty or mo side. Of the latte shundred miles l northeast uncove probably the who east, before its me Agassiz to be dra The Nelson, as along its course o Hudson Bay. Th only a few degre Playgreen. Pipest it turns to the ea Lake; and finall hundred miles. is approximately below Lake Winn 410 and 420 feet a

the sea level.

About four fiftlesins of the Recthe Saskatchewan the Rainy and Waheet and were triward outlet. The carried along the Gulf of Mexico.

Mately 250,000 squalely 250,000 squalely 250,000 squarely distributed to the lake itself. In the standard by extended north be the Nelson to include the Mackenziand the Mackenziand the Mackenziand the Mackenziand spirit for the standard the Mackenziand the Mackenz

by the waning ice

the area of the g

miles, to the foot

Nelson is naviga

Limestone Rapid.

¹ Report of the Assiniboine and Saskatchewan Exploring Expedition, 1859.

ed between the of the plateau

xt to its mouth relinquished by se, long before e most western its mouth is a naximum width ts two branches n Rivers, unite

The elevation s crossed by the ow, 1.619 feet atchewan, about Saskatchewan feet above Lake informs us that viftly;" and he nd its mouth it age descent per e Saskatchewan lred miles above rd of a mile m gable by steam

ely, the Winnie s, about a dozen

streams varying in length from ten to forty miles enter its west side, Smaller and twenty or more of similar or somewhat greater length enter its east LakeWinnipeg. aide. Of the latter the largest are Beren's and Poplar Rivers, each about a hundred miles long. The recession of the ice-sheet from southwest to northeast uncovered the entire region west of Lake Winnipeg, and probably the whole of the country traversed by these streams on the east, before its melting finally permitted the waters of the glacial Lake Agassiz to be drained to the level of this lake. The Nelson, as before noted, is bordered by no areas of highland

slong its course of about four hundred miles from Lake Winnipeg to Hudson Bay. The upper half of this river flows in a general direction a few degrees east of north, passing through Great and Little Nelson River. playgreen. Pipestone, Cross and Sipi-wesk Lakes, to Split Lake; thence aturns to the east for about a hundred miles, passing through Gull Lake; and finally takes a northeastward course along its lower one hundred miles. According to Dr. Bell's observations, Sipi-wesk Lake gapproximately 570 feet above the sea, or a hundred and forty feet below Lake Winnipeg; Split and Gull Lakes are respectively about 40 and 420 feet above the sea; and the descent in the next forty-eight miles, to the foot of Broad Rapid, is nearly three hundred feet. The Yelson is navigable from the sea about ninety miles to the First Limestone Rapid, where the elevation is probably about fifty feet above the sea level.

About four fifths of the area drained by the Nelson, including the lasins of the Red River of the North, the Little Saskatchewan and e on the North the Saskatchewan, and the greater part or possibly all of the basin of eyond the control of the Rainy and Winnipeg river system, were uncovered from the ice-outh Saskatche sheet and were tributary to Lake Agassiz while it still had its south-exceeding 2.200 ward outlet. The waters of a large part of British America were thus low stages are carried along the course of the Minnesota and the Mississippi to the places to width Gulf of Mexico. The basin of Lake Agassiz then included approxi-Area of the basin of Lake ed by low sandy mately 350,000 square miles, of which nearly a third was covered by Agassiz. iles from these the lake itself. In the later stages of this glacial lake, when it flowed elevation three portheastward by outlets higher than the Nelson, its basin probably pting along tiggerended north beyond the present water-shed of Lake Winnipeg and through a broad the Nelson to include the upper portion of the basins of the Churchill ry are only fifty and the Mackenzie, the lower course of these rivers being obstructed nerally low add, by the waning ice-sheet. It seems probable that with this addition the area of the glacial lake basin was not less than 500,000 square miles.

DRIFT FORMATIONS IN MANITOBA.

Thickness of the drift in Manitoba.

The thickness of the sheet of superficial deposits overlying the bel. rock in West Selkirk is 65 feet; in Winnipeg and Saint Boniface is varies from 30 to 80 feet; near Niverville it is from 65 to 100 feet; is Dominion City, near Letellier, and on the Low farm west of Morris in is at least 170 to 250 feet, and in West Lynne at least 108 feet; at Rosenfeld it is 143 feet; near Carman it is about 100 feet; and seven miles west of Portage la Prairie, 158 feet. From these records it seems probable that the thickness of these deposits upon the flat plain of the Red River Valley in Manitoba averages about a hundred feet, consider ably exceeding this, to a maximum of 150 to 250 feet, along the central part of this area south of the Assiniboine, but not probably averaging more than 50 feet in the lower part of the valley between Winnings and Lake Winnipeg, where the higher portions of the bed-rock rise to the surface. On the Archean area of the east part of Lake Agassiz plentiful rock-outcrops occur about Rainy Lake and the Lake of the Woods, westward along the Canadian Pacific Railway nearly to the Whitemouth River, and in the country east of Lake Winnipeg; and is probable that the average thickness of the superficial deposits in that extensive district is not more than 30 to 50 feet. West of Lake Agassiz, many portions of the plateau bordered by the Pembina Monna tain and the Tiger Hills have only a small depth of drift, ranging from a few feet to 20 or 30 feet, but in some places the drift appears t extend deeper, as shown by stream valleys, and its average thickness may be 40 feet or more.

Distribution of the till.

Till, also called boulder-clay, constitutes the greater part of the entire sheet of superficial deposits, both within the area of Lake Agassiz and upon the adjoining country. It usually lies on the striated bed-rock and upon large areas it reaches thence upward to the surface; but else where this unmodified glacial drift is covered by modified drift, the stratified gravel, sand and clay deposited by streams which flowed down from the ice-sheet during its melting, or by lacustrine and fluvia, sediments. Fully half of the area of Lake Agassiz in Minnesota and North Dakota has a surface of till; but in the part of this lake area examined in Manitoba its proportion is less, because much of this district is covered by the Assiniboine delta and its associated lacustring Tracts of till forming the source within the area of Lake side of the Big Grass Marsh, from the south end of Lake Manitobs the area of Lake side of the Big Grass Marsh, from the south end of Lake Manitobs the Red River and Winnipeg and beds. Extensive tracts of till, however, occupy the surface on the south to the Canadian Pacific Railway, from East Selkirk eastward along this railway, and ten miles east of Emerson, where the flat plain

the Red River forms the surface tain escarpment Beneath the delt tion of the flat commonly fine s and the bed-rock

The till is the sisting of clay, s on unstratified Very finely puly its principal ing It has a dark b vellowish to a d commonly betwe due to the influe deposit, changing binations to hydr fill is that its up below there is a must be picked a cause of this diffe of the ice-sheet t contained in the side of Lake Age surface. Within smoother and m manner of deposi feet stratification Yet even where

Boulders are f their abundance and in the least size extends up t especially in the sizes up to ten or ninety-nine per consists of Archa the Archaean ar occasional limes stones, constituti

than like ordina

through its entir

orlying the bed. aint Boniface it to 100 feet; in est of Morris, it

Α.

ist 108 feet; al feet; and seven records it seems flat plain of the ed feet, consider. long the central bably averaging tween Winniper bod-rock rise to f Lake Agassiz the Lake of the y nearly to the innipeg; and it

icial deposits in West of Lake Pembina Mong. ft, ranging from drift appears t vorage thickness

art of the entire ake Agassiz and triated bed-rock urface; but else dified drift, the s which flowed trine and fluvial

Minnesota and f this lake area e much of this ciated lacustrine surface on the wa, on the east Lake Manitoba Winnipeg and elkirk eastward

re the flat plain

of the Red River Valley is bordered by slightly higher land. Till also forms the surface of the terrace along the foot of the Pembina Mountain escarpment between the international boundary and Thornhill. Reneath the delta doposits of gravel and sand, and on the central portion of the flat plain of the Red River Valley, where the surface is commonly fine silt or clay, a sheet of till lies between these sediments and the bed-rock.

The till is the direct deposit of the ice-sheet, as is shown by its con-Characters of siding of clay, sand, gravel, and boulders, mingled indiscriminately in the till. an unstratified mass, without assortment or transportation by water. Very finely pulverized rock, forming a stiff, compact, unctuous clay, is its principal ingredient, whether at great depths or near the surface. has a dark bluish gray color, except in its upper portion, which is rellowish to a depth that varies from five to fifty feet, but is most commonly between fifteen and thirty feet. This difference in color is due to the influence of air and water upon the iron contained in this deposit, changing it in the upper part of the till from protoxide combinations to hydrous sesquioxide. Another important difference in the fill is that its upper portion is commonly softer and easily dug, while below there is a sudden change to a hard and compact deposit, which must be picked and is far more expensive in excavating. The probable cause of this difference in hardness was the pressure of the vast weight of the ice-sheet upon the lower and older till, while the upper till was contained in the ice and dropped loosely at its melting. Upon each side of Lake Agassiz the till has a moderately undulating and rolling surface. Within the area that was covered by this lake it has a much smoother and more even contour, and its upper portion, owing to its manner of deposition in this body of water, sometimes shows an imperfeet stratification, with a scantier intermixture of boulders and gravel. Yet even where it has distinct lamination, it usually is more like till than like ordinary modified drift, and contains stones and gravel though its entire mass.

Boulders are frequent or plentiful in the till throughout Manitoba, their abundance being nearly the same as in northeastern Minnesota and in the least rocky parts of New England. Their usual range in size extends up to a diameter of four or five feet; but in a few localities, especially in the course of morainic belts, they were observed of all izes up to ten or twelve feet cubes. Generally as large a proportion as Boulders and mety-nine per cent, of the boulders exceeding one foot in diameter gravel from Archaean and consists of Archæan granite, gneiss and schists, being derived from formations, the Archean area on the northeast and north. With these are occasional limestone blocks, derived from the belt of Paleozoic limestones, constituting on the average perhaps nearly one per cent. of the

large rock fragments of the drift. The bedded and jointed characters the limestones has prevented their supplying many large boulders in comparison with the more massive crystalline Archæan rocks, while

yet usually about half of the smaller cobbles and pebbles in the till and

Northeastern limit of limestone drift.

t, in gravel and sand deposits are from these Pakeozoic limestones. But east of Lake Winnipeg and northeast of a line drawn from this lake southeastward across the Lake of the Woods to the west end of Rajay Lake, both boulders and gravel of limestone are absent or exceedingly rare. This line probably marks the eastern limit of the glacial current that moved south-southeast in the vicinity of Winnipeg and at Blace

rare. This line probably marks the eastern limit of the glacial current that moved south-southeast in the vicinity of Winnipeg and at Black Bear Island near the Narrows of Lake Winnipeg, carrying débris from the limestone region of the Manitoba lakes. Upon the Cretaceous area a considerable proportion of the gravel and cobbles is derived from the Fort Pierre shale, but this formation supplies no large boulders.

Localities of abundant and large boulders. Fort Pierre shale, but this formation supplies no large boulders.

The following localities may be mentioned as having especially abundant boulders. On the slope of the Pembina Mountain, in T.:

R. 6, between Morden and Thornhill, very plentiful and large bouldes.

Star Mound,

are spread upon an area of several square miles, as noted in the description of the Tintah beaches. The sides of Star Mound, especially those facing the north and northeast, are strewn with a multitude boulders, nearly all granitic, of all sizes up to five feet in diameter rarely larger. These were probably combed out of the ice-sheet in is passage over this hill. Comparatively few boulders occur on the smalflat area at its top. Pilot Mound, an equally prominent hill seen from

Pilot Mound.

ceous shale with thin covering of drift, but it has no such unusian profusion of boulders on its slopes. Rock Lake, through which the Pembina flows, derives its name from the remarkable abundance of boulders, mostly granitic, up to six feet or more in diameter, bordering its shores; and along a distance of one or two miles west from this last

this looking toward the northwest, is like Star Mound a knob of Crela-

Rock Lake.

the Pembina Valley is much encumbered with boulders, which in somplaces are accumulated upon small morainic ridges and knolls. The largest boulder noted in this exploration, having nearly twice the size of any other observed, is a block of dark gray granitoid gneiss, 22 feel long, 8 to 14 feet wide, and projecting 2 to 5 feet above the surface, it the N. W. 4 of sec. 9, T. 1, R. 4 E., on the low ridge ten miles east of

East of Emerson. the N. W. ‡ of sec. 9, T. 1, R. 4 E., on the low ridge ten miles east of the smaller. Among the other plentiful boulders of that vicinity, now were seen exceeding seven or eight feet in dimension. Like many of the smaller boulders throughout this prairie region, this block is surrounded by a slight depression, one to three feet below the adjoining ground; and a careful examination shows that some of its projecting corners and edges are smoothly polished. These depressions were formed by the trampling and pawing of buffaloes in rubbing upon the

EMAV.]

boulders, which as could be done

A belt of more the ice-sheet during its retree Agassiz on the Pembina Rivers exploration for the baye attempted

Dakota and of M

boundary of the

or Herman beach

Evidence which

report, in treatin

ake, leads me to
the recession of
north as the latit
peg and Manitob
of this valley t
abmount boulder
ietween Morden
on the east marg
and remarkable
shore of Lake A
bakota, seem ref
The west side of

two or three earl

of which Dr. G.
region, with an a
gradually upware
a its highest poin
slopes and ridges
ance, and these a
western is more
prominent ridges
with the interve
Large areas of co
are however, four
appears to be tha
modified by subse

Bulletin No. 39, U. 8

ited characterol arge boulders in onn rocks, while es in the till and mostones. Bu n from this lake est end of Rainy t or exceedingly glacial current eg and at Blad ying débris from

Cretaceous area

derived from the

boulders. aving especially ountain, in T.3 d large boulders is noted in the ound, especially h a multitude o et in diameter (e ice-sheet in its cur on the small nt hill seen from a knob of Creta no such unusua rough which the le abundance o meter, bordering st from this lake s, which in som and knolls. The ly twice the size

en miles east at vicinity, non Like many this block is su ow the adjoining of its projecting epressions wer ubbing upon th

id gneiss, 22 feet

e the surface, it

boulders, which were thereby sometimes worn and polished as perfectly Boulders as could be done by art.

A belt of morainic drift deposits, accumulated along the border of the ice-sheet during one or more pauses or times of re-advance inter-morning in rapting its retreat, was observed upon the country that adjoins Lake Manitoba. Agassiz on the west and is crossed by the Assiniboine, Souris and Pembina Rivers. Though sufficient time was not available in this exploration for tracing the entire course of this recessional moraine, I have attempted to correlate it provisionally with the moraines of North bakota and of Minnesota, thus indicating the probable course of the boundary of the ice-sheet at the time of the formation of the highest or Herman beach of Lake Agassiz,

Evidence which is more fully detailed in the ensuing parts of this report, in treating of the modified drift and the history of this glacial lake, leads me to believe that the Red River Valley was uncovered by the recession of the ice-sheet and was occupied by this take as far north as the latitude of Winnipeg and the south end of Lakes Winnipeg and Manitoba, while the ice still extended south on the west side of this valley to Devil's Lake and Turtle Mountain. The very on the east abundant boulders noted on the east slope of the Pembina Mountain Pembina between Morden and Thornhill were probably deposited at this time southward. on the east margin of this ice-lobe that reached south to Devil's Lake; and remarkable crescent-shaped moraines observed on the highest shore of Lake Agassiz in the southwest part of Walsh County, North Dakota, seem referable to the same time and manner of deposition.

The west side of this Dakota lobe of the ice-sheet during this and two or three earlier stages of its recession rested on Turtle Mountain, of which Dr. G. M. Dawson writes:—"It is a broken, hilly, wooded Mogainie drift region, with an area of perhaps about twenty miles square, and slopes on Turtle Mountain gradually upward from the plain around it, above which it is elevated, described by Dr. Dawson. atits highest points, about 500 feet. . . . Nearly all the abrupt slopes and ridges-of which there are many-show boulders in abundance, and these appear to be chiefly of Laurentian rocks. . . . The western is more abruptly hilly than the eastern side, and the more prominent ridges have a general northerly and southerly direction, with the intervening valleys characterized by swamps and lakes. large areas of comparatively level or only gently undulated ground are however, found in some places. The surface of the 'mountain' appears to be that of the drift, as deposited, and has been but little modified by subsequent sub-aerial action. The lakes lie in basin-like

Bulletin No. 39, U. S. Geological Survey, p. 61.

hollows, and notwithstanding their great number, drainage valley, and stream courses are few and unimportant," 1

Stages in the recession of the ice-sheet west and north of Turtle Mountain.

The outermost moraine marking the farthest advance of the in. sheet in the last glacial epoch passes along the Coteau du Misson crossing the international boundary in its northwestward course above a hundred and fifty miles west of Turtle Mountain. Between this Altamont moraine and the Fergus Falls and Leaf Hills moraines, whi are probably contemporaneous with the great moraines close south of Devil's Lake and on Turtle Mountain, several distinct stages in the recession of the ice-sheet are recognizable by morainic deposits Iowa, Minnesota, and South and North Dakota. The morainic deia of Turtle Mountain apparently represents two or three stages in the glacial recession, and in the country lying on the west and northwest numerous morainie belts will doubtless be found beyond the limited my exploration. The moral e observed by me in southwestern Manitoba belongs to

a time somewnat later than the great moraines of the Leaf Hills. 4. south side of Devil's Lake and Turtle Mountain; but it is believed a by contemporaneous with the accumulation of the boulders east Thornhill and the moraines of southwestern Walsh County before mentioned, and with morainic hills on the north side of Devil's Lake The most southern part of its observed course extends northerly from the east end of Turtle Mountain by Killarney to the northern part of Pelican Lake, a distance of about twenty-five miles. Thence it extends west-northwest twenty miles, forming the west part of the Tiger Hills in their extent along the north side of Lang's Valley and the Souris T. 7, R. 19, where it again bends to the north and holds that come ten or twelve miles to the prominent Brandon Hills. Here again it Moraine of the turns to the west, making a sharp angle, but within a few miles and Arrow sinks to the general level of the adjoining country and loses its distilled. tive character. Proceeding onward to the west about twenty mile this moraine is next found on the north side of the Assimiboine a few miles northwest of Griswold, and thence it takes a northwest course lying mostly from five to eight or ten miles northeast of the Asia boine and approximately parallel with it to the Arrow River and Bid Tail Creek, beyond which I have no definite information of its fartle course. On both sides of the Arrow River it rises in prominent eless tions, with characteristically rough contour and plentiful boulders, at this portion is called the Arrow Hills. The ascertained extent of it. moraine, known in successive parts as the Tiger, Brandon and Arm Hills, is about a hundred and twenty-five miles. Its general courses

. FriAMe

northwest, but v the Pembina, c about twenty-fiv dented by two re the Tiger Hills of Pelican Lake, dammed by the the course of thi mound the sout tributary to Lak A conspicuous R. 16, two to thr morainic hills ris being 1,550 to 1,5 quarter of a mil enclosed by these is very gravelly fragments being g but nowhere abu diameter. This t to Lang's Valley, small proportion of irregular hills and west in sec. 19, an the south-south ast, beyond an in consisting of a slig n hillocks and s mominent in sec. restern bluff of Po

the north. On Ill in sec. 2, T. 6. kes, Lang's Val oward the Turtle restern part of the roken outlines th ounded massive hi

Within five mile

his moraine is typ

regularly groupe

ket above the inte

a. Notman's Hi

hat smooth sheet

¹ Report on the Geology and Resources of the region in the vicinity of the Forty-ninth Para-DD. 228, 224.

ainage valleys

ice of the bea du Missouri d course about Between this ioraines, whi close south of t stages in the ic deposits i morainie deie e stages in the

and northwest

nd the limits

oba belongs to Leaf Hills, the t is believed to boulders east of County before of Devil's Lake northerly from iorthern partor hence it extends the Tiger Hills nd the Sourists

olds that course

Here again i a few miles loses its distin t twenty mile ssiniboine a few orthwest course of the Assim River and Bid on of its fartle rominent eless ul boulders, a: I extent of the idon and Arm eneral course

Forty-ninth Paralle

morthwest, but within the Souris basin and that of the head streams of the Pembinn, on the north side of Turtle Mountain, it is deflected shout twenty-five miles to the northeast. The ice-sheet was there indented by two re-entrant angles, one having its apex in the range of the Tiger Hills near Poor's Lake, a few miles north of the north end of Pelican Lake, and the other in the Brandon Hills. A glacial lake, dammed by the ice-sheet and probably causing its indentations along the course of this moraine, then filled the Souris basin and outflowed around the south side of Turtle Mountain and Devil's Lake, being tributary to Lake Agassiz by the Sheyenne.

A conspicuous portion of this mornine was examined in sec. 19, T. 4, R 16, two to three miles west of the middle of Pelican Lake. Here Sec. 19, T. 4. morainic hills rise 40 to 60 feet above the general level, their tops Pelican Lake. being 1.550 to 1,575 feet above the sea. A beautiful lakelet, about a anarter of a mile long and said to have a depth of fourteen feet, is enclosed by these hills near the center of the section. Their material k very gravelly till, not water-worn, about half of the small rock naments being granite and half limestone. It also contains frequent, but nowhere abundant, granitic boulders up to two or three feet in diameter. This till, like that of the flat country north and northwest to Lang's Valley, and of the Tiger Hills beyond, includes only a very amail proportion of gravel from the Fort Pierre shale. These roughly irregular hills and hillocks occupy a width of a half mile from east to west in sec. 19, and extend more or less noticeable in a narrower belt the south-southwest at least five miles. Toward the north-northast, beyond an interval of one mile of the plain like that on each side, consisting of a slightly undulating sheet of till, the moraine re-appears m hillocks and short ridges 20 to 40 feet high, becoming most prominent in sec. 32 of this township, near the verge of the southwestern bluff of Pelican Lake.

Within five miles northward from the north end of Pelican Lake, his moraine is typically developed around Poor's Lake, consisting of regularly grouped hills, knolls and ridges of till, rising 50 to 100 get above the intervening hollows, to 1,550 and 1,600 feet above the Ka. Notman's Hill in sec. 15, T. 6, R. 16, is one of its outlying knobs in the north. On the southwest side of this morainic belt, Lookout Ell in sec. 2, T. 6, R. 17, affords a fine prospect of Pelican and other kes, Lang's Valley, and the flat plain that rises thence slowly ward the Turtle Mountain. The morainic drift here spread over the West part of estern part of the Tiger Hills gives to this range more knolly and the Tiger Hills. token outlines than along most of its extent farther east, where its punded massive hills of Cretaceous shale are only covered by a somehat smooth sheet of till that commonly varies from a few feet to

twenty feet in thickness. In contrast with this, along the western morainic portion of the range, extending from Notman's Hill and Poor's Lake west-northwest across the Souris, the thickness of the drift probably averages 100 to 150 feet,

The road from Langvale post office, in Lang's Valley, to Gregory's Between Lang's Valley, to Gregory's Valley and The road from Langvale post office, in Lang's Valley, to Gregory's will on the Souris, five miles to the north, crosses this morainic help of the Tiger Hills, which there is three to four miles wide and has a surface of many hills and short ridges, with typical morainic contour rising in elevations mostly 20 to 50 feet above the intervening depres

Big Tiger Hill, sions. It is a half mile east from this road to the top of the Big Tiger Hill, which is the highest point of the entire range, about 1,640 feet above the sea, being nearly 300 feet above Lang's Valley. The elevation of the road on the west is about 1,525 feet, and of its highest place one and a half miles north-northwest of this hill, about 1,570 fee All this portion of the range is till, but it has fewer boulders than an usually found on morainic areas, though they are probably twenty time as abundant as on the plain southward. Small rock fragments, rarely water-worn, are very abundant, nearly all Archican granitoid gheist and Palæozoic limestone in about equal proportions, with little or a shale. Looking west-northwest from the Big Tiger Hill, this belt d rolling morainic hills is seen extending ten miles along the northead side of the Souris at an elevation of about 1,575 feet. South of a Souris and thence southeast to the moraine west of Pelican Lake, vast flat expanse is seen rising slowly from an elevation of about 1,475 feet at its verge bordering the Souris and Lang's Valley to about 1,700 feet at the northern base of Turtle Mountain, which rises 2,000 feet or more in the blue distance thirty miles south-southwest

thorge cut by through the Tiger Hills.

In the central part of T. 6, R. 18, two miles west of the Big Tild Hill, the Souris cuts through this moraine by a very picture sque goes that extends four macs north from its Elbow. The stream in t distance descends approximately from 1,265 to 1,210 feet above the sea, its channel being in many places obstructed by boulders but having no considerable abrupt fall. The width of the gorge is a half milet one mile between the tops of its steep sides, which rise in their highs portion 350 feet from the river to the crest of the morainic belt, some places along the southern part of the gorge the Fort Pierre sh is exposed by recent erosion to a height of 100 feet or more above the river; but it has only low outcrops near Gregory's mill at the north; boundary of the moraine. The Souris there and through its next or six miles northeast to Souris City has eroded its channel to a depl of about 140 feet in a smooth sheet of till, only reaching the und lying shale in a few places, without cutting deeply into it. This expans of till has a descent of several feet to the mile, nearly the same as the

the Souris its

margin adjoins the

19 this morainic b

elevation of 1,350 Souris, it is strewn ton feet in diamete From the west o

Hills, having throu unon a width of fo bet above the sea. rises to 1,550 and 1 most prominent clu farther north and 85, T. S. R. 18. Vi and from Brandon e

aspicuously, havi rest, which is 1,575 most eastern ridge. akes here from a r g very steep slopes 630 feet along its c naslightly crooke pproximately 1,556 fgravelly drift, pri ery plentiful boulde

mall rock fragment helarge boulders be Lichster lies one t f this ridge, and so at with trend from liges the prospect to torainic knolls and s

on of 1.450 to 1.550 le east to west mora dicining country of est, from Plum Cree meath delta deposita On the north side

ominently in the w Griswold. The chi ep. mainly or wholl egeneral surface or efirst six miles nor the western n'- Hill and kness of the

o Gregory's orainic belt de and has a inic contour ming depreshe Big Tiger nut 1,640 feet Talley. The of its highest mit 1.570 feet dors than are twenty time ments, rarely anitoid gneis: th little orn II. this belt of

the northeast South of % elican Lake, tion of about alley to about which rises to h-southwest. the Big Tigg turesque go p tream in thi feet above the lers but havir a half milet n their higher ainie belt. rt Pierre sha nore above the

at the norther gh its next: nnel to a dept ing the unde t. This expan ie same as th

the Souris itself, toward the Assiniboine, Where its southern vicinity of margin adjoins the moraine, in the vicinity of Gregory's mill, at an Gregory's Mill. elevation of 1,350 to 1,360 feet above the sea, or 150 feet above the Souris, it is strewn with multitudes of granitic boulders up to eight or ten feet in diameter.

From the west end of the Tiger Hills in the south part of T. 7, R. Brandon Hills. 19 this morainic belt curves to the north and is called the Brandon tills, having through this township a characteristically knotly contour mon a width of four or five miles, with an elevation 1,450 to 1,500 bet above the sea. In the southeast part of T. 8, R. 19, the moraine rises to 1,550 and 1,600 feet, attaining about the same height as the most prominent cluster of these Brandon Hills, which lies a few miles farther north and northeast, in the northern part of secs. 31, 32, and 23 T. S. R. 18. Viewed from the Souris and Assiniboine on the east and from Brandon on the north, this cluster of hills stands forth very conspicuously, having a steep ascent of about 250 feet from base to rest, which is 1,575 to 1,610 feet, approximately, above the sea. The most eastern ridge, running to the apex of the angle which the moraine makes here from a northern to a western course, is narrow and bounded g very steep slopes, having an osar-like form, with undulations of 20 an feet along its crest, which extends about three fourths of a mile na slightly crooked course to the N. or N. 10° E., having a height upproximately 1,550 to 1,575 feet. The surface of this ridge consists gravelly drift, principally not water-worn, with frequent but not ery plentiful boulders up to five feet in diameter. About half of the mall rock fragments are Archaean and half limestone, but nearly all lelarge boulders belong to the former. The highest portion of this Illeluster lies one to two miles west-northwest from the highest point this ridge, and seen at that distance it appears as a similar ridge at with trend from east to west. Within the angle between these ides the prospect to the southwest overlooks a very uneven tract of prainic knolls and small ridges irregularly grouped, having an elevaon of 1.450 to 1.550 feet. In the northern part of T, 8, R. 19 and 20, he east to west morainie belt sinks and becomes indistinct from the joining country of undulating till which rises westward; and farther est, from Plum Creek to Griswold and the Assiniboine, it is concealed eneath delta deposits of sand.

On the north side of the Assiniboine this moraine again rises North of the eminently in the west half of T. 10, R. 23, three to six miles west Assiniboine. Griswold. The channel eroded by the river here is about 200 feet ep mainly or wholly in drift, the river being about 1,200 feet and egeneral surface on each side about 1,400 feet above the sea. In efirst six miles north from the Assiniboine the moraine attains a

height 50 to 100 feet or more above the adjoining country, the tops of its irregular hills and ridges being 1,450 to 1,550 feet above the Thence this belt of drift hills, having an average width of three or four miles, continues northwest diagonally across T. 11, R. 24 at west half of T. 12, R. 24, and the northeast part of T. 12, R. 25 th south and west parts of T. 13, R. 25, and the east half of T. 13, R. 26 In the two townships last named its hills rise 100 to 150 feet always the country on the east and west; and from the name of the river which intersects it in the north edge of T. 13, this part of the moraine's known as the Arrow Hills. Farther northwest, where its continuation crosses Bird Tail and Snake Creeks, the surface, though not promin-

Extent of the moraine.

Arrow Hills.

ently hilly, is rough and unusually strewn with boulders, Enough of this moraine is thus known to show that at the time glacial recession to this its formation the ice-sheet had so far retreated from its former wester boundary on the Missouri Coteau as to uncover the entire length of the Qu'Appelle and the Assiniboine for nearly sixty miles below the mouth of that river, to Oak Lake. The significance of this will appear more fully on subsequent pages relating to the Saskatchewan and Saskatchewan glacial lakes, the latter of which extended at this time from a southern bend of the Souris in North Dakota to the Assiniboine and the lower Qu'Appelle.

Modified drift bordering
Rainy River
and the
southwest part
of the Lake of
the Woods.

Modified drift, consisting of stratified gravel and sand, overlies the bed-rocks and the till, and generally forms the surface on an extension area about the southwest part of the Lake of the Woods and along the Rainy River. Southward similar deposits cover large tracts in Minns sota, reaching to the lakes at the sources of the Mississippi and to a Leaf Hills, and thence southeastward to Minneapolis and Saint Pal, The contour of the greater part of these deposits is flat or moderate undulating, and their surface varies in height from a few feet to fill feet or rarely more above the adjoining lakes and streams. In cental Minnesota these tracts of gravel and sand have an elevation that it creases from south to north, being 825 to 950 feet in the vicinity Minneapolis and Saint Paul, rising gradually to 1,200 feet in their tance of about a hundred miles northwest to Brainerd, and rang from 1,350 to 1,500 feet between the Leaf Hills and Itasca La Thence their surface sinks to 1,150 and 1,075 feet in the vicinity Rainy River and the Lake of the Woods. West of this lake gas and sand cover most of the country for nearly seventy-five miles; the upper part of the Roseau, Rat, and Seine Rivers, declining in deposits continue to a remarkable group of osars and small platears gravel and sand, between 750 and 875 feet above the sea, sever

direction to about 900 feet above the sea. Northwestward t continuation south into Minnesota, and northwest to Bird's Hill, Winnipeg, fifteen miles east-northeast of Winnipeg, of which Bird's Hill, be the Canadian

most conspicuo

This broad 1 and deposits o northwest about north to the R Winnipeg, it li this belt is bor which have mos height of the ti that of the und pread as a shee in their elevation sand and gravel average thickne 400 to 600 feet a nart of both the the former bein other portions knolly and hilly 100 to 200 feet, a ing country. In wiefly of till w

rathered clay, sar of the ice. During the rap Becessive morain nd volume, and b hit, spreading it beyond the ice-ma ravel and sand,

mosts of stratifie

was brought by

time of accumula

of modified drift,

short ridges of

been heaped up w

were spread out 1

ng power, upon

he lower part of

ated by Chamb

try, the tops of

t above the sea

idth of three o

. 11, R. 24, ()

T. 12, R. 25, the

of T. 13, R. 26

60 feet above t

the river whish

f the moraine is

e its continuation

ugh not promin

at at the time

s former weste.

entire length

miles below the

f this will appear

hewan and Som

s time from to

Assiniboine a

sand, overlies in

ee on an extens;

ods and along :

e tracts in Mia.

sissippi and to

is and Saint Pag

flat or moderates

a few feet to in

eams. In cents.

elevation that

in the vicinity

200 feet in the

nerd, and ranging

and Itasca Lak

in the vicinity

f this lake gra

enty-five mile

declining in !

thwestward to

d small plateau

the sea, sever

Bird's Hill, lo.

ers.

the Canadian Pacific Railway, is the most western and one of the most conspicuous.

This broad belt of country, characterized by extensive gravel and sand deposits overlying the till, reaches from south-southeast to northnorthwest about four hundred miles. From Red Lake in Minnesota north to the Rainy River, the Lake of the Woods, and the vicinity of Winnipeg, it lies within the area of Lake Agassiz. On each side Adjoining areas this belt is bordered by areas of nearly the same general elevation associated which have mostly a surface of till; and it is to be remarked that the moraines. height of the tracts of modified drift and till are alike determined by that of the underlying rocks on which these superficial deposits are pread as a sheet of slight depth in comparison with the gradual change their elevation. The drift sheet on this belt, including both the and and gravel and underlying deposits of till, probably varies in its aggrage thickness from 50 to 150 feet, while its central portion rises un to 600 feet above its south and north ends. Though the greater part of both the modified drift and till have only slight undulations, the former being often nearly flat and the latter moderately uneven, wher portions are crossed by moraines which have a prominently kaolly and hilly contour, rising usually 25 to 75 feet, or occasionally 100 to 200 feet, and in the Leaf Hills 100 to 350 feet, above the adjoining country. In some places the belts of morainic hills, consisting diefly of till with abundant boulders, are bordered on one side by gaets of stratified gravel and sand which slope slowly downward from tiem and are merged in the extensive plains or moderately undulating grees of this modified drift, showing that a part of the gravel and sand was brought by streams that descended from the ice-sheet during the time of accumulation of its moraines. Besides these overwash slopes Kames. of modified drift, the morainic belts often include knolls, hillocks, and sport ridges of sand and gravel, called kames, which seem to have een heaped up where such streams left their ice-walled channels and were spread out more widely, thoughy losing their velocity and carryng power, upon the adjoining land surface. These deposits show that he lower part of the ice-sheet enclosed much drift material, denomiated by Chamberlin englacial drift, from which the glacial streams sthered clay, sand, and gravel, and spread them beyond the border f the ice.

During the rapid melting of the ice in its times of retreat between Osars. arcessive moraines, the glacial streams attained their greatest extent pl volume, and brought proportionately extensive deposits of modified rift, spreading it mainly in plains or moderately undulating tracts eyond the ice-margin, but here and there leaving prolonged ridges of ravel and sand, called osars, which were formed in their channels

Deposition of the melting ice-sheet.

between walls of ice.* The distribution of the modified drift, thus found the modified difficulty and th while it is very scantily developed on a still wider region of Minnesota North Dakota, and Manitoba southwest of this belt, and likewise is scanty or wanting on its northeast side in northern Minnesota and about the northeast and north portions of the Lake of the Woods seems to be attributable to converging slopes of the surface of the ice-sheet and the consequent convergence of its currents, which brought an unusual amount of englacial drift into the ice along this helt, and by which also the streams produced in its melting were caused to flow thither from extensive areas of the ice on the east and west. The glacial strice of these adjoining areas show that on the east the course of the motion, and the descent of the surface, of the ice-sheet Web from northeast to southwest, but that on the west the glacial current moved, and the ice surface sloped, toward the southeast. On the east drift limestone is absent or very rare, because no limestone formations were crossed within several hundred miles by that part of the jo. sheet; but on the west the drift contains much fine limestone detring sand and gravel, and frequent boulders of limestone, borne southeast ward from Manitoba over the Archean area of the southwest part the Lake of the Woods, of Rainy River, and of northern and central Minnesota. In the same directions with the slopes of the ice surface. which are known from the courses of the glacial strike and the tranportation of the drift, the streams of the glacial melting flowed convergently from the east and west, from the ice over northern Minneson and eastern Manitoba on one side, and from that over the Red River Valley and western Manitoba on the other, toward this belt of plenting superficial deposits of gravel and sand.

Group of osars northeast of Winnipeg.

Prominent osars begin at Bird's Hill, the first station of the Canadia, Pacific Railway northeast of Winnipeg, from which it is seven miles distant, and extend thence seven or eight miles east-northeast and a equal distance southeast. The southern and southeastern portion this group comprises many low ridges of gravel and sand five to fifteen feet high, trending from northwest to southeast; also somewhat rounded mounds, as Oak Hummock in the S. E. 1 of sec. 12. T. II. R. 4 E., which rises about thirty feet above the adjoining country, with its top approximately 810 feet above the sea; and occasionally massive and conspicuous hill, as Moose Nose in secs. 29 and 30, T. II

Fig.3. Secti

Fig. 4. Sect Intern

Fig. 5. Sect

Fig. 6. Sec

TILL

Arden

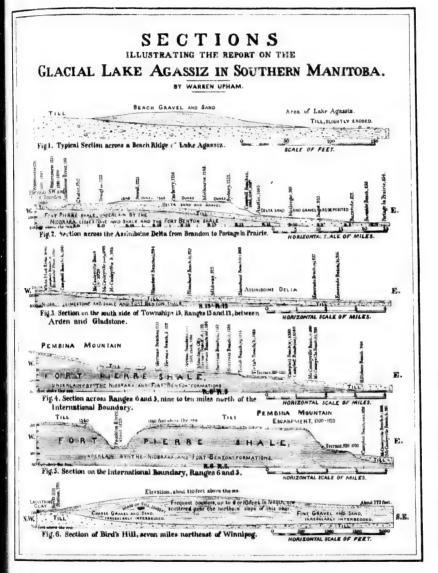
[.] The discrimination of the two classes of gravel and sand deposits named thus ka osars was advocated by W. J. McGee in the Report of the International Geological Corp. second session, Boulogne, 1881, p. 621; and by T. C. Chamberlin, in the Third Annual Rej. the U.S. Geological Survey, for 1881-82, p. 299, and Am. Jour. of Science, III, vol. xxx May, 1884, p. 389. President Chamberlin shows that the latter term, in this Anglicized for has long been in common use by Jackson, Hitchcock, Desor, Murchison, and other writers.

lrift, thus found il to Winnipeg. n of Minnesota and likewise is Minnesota and of the Woods. surface of the which brough g this belt, and caused to flow and west. The east the course ice-sheet were glacial current st. On the east tone formations part of the jo. restone detritus. orne southeast. ithwest part ern and central the ice surface. and the transing flowed conthern Minneson the Red Rive

of the Canadia, t is seven miles ortheast and a tern portion and five to fiften also somewhat see, 12, T. H. ig country, with occasionally occasionally 9 and 30, T. E.

belt of plentin.

amed thus kame.
Geological Congreird Annual Reporience, III, vol. vo. this Anglicized for d other writers.



R. 5 E., which country around north, in secs. 3 R. 4 E., through R. 5 E., these d one mile wide, above the sea which on the no and four miles l again rise in pla culminating in above the soa, o two miles distar posed of grave deposits formed between walls o whose melting l ately steep slop the completion deposits, they sa deep; and the is sarface were dre southwest, they 750 to 760 feet a they are connec

sand which reac Woods and into An instructive of its gravel and from the railwa half mile southe the plateau of se a mile from the plain that exten is 759 feet, and It has a broadly

its northern slop ing in width fro thirty feet. The crest of the Eill. deposit is seen to pubbles and rock

R. 5 E., which projects sixty feet above the average of the nearly flat country around it, rising to about 840 feet above the sea. Toward the north, in secs. 35 and 36, T. 11, R. 4 E., and again from sec. 2, T. 12, R. 4 E., through a distance of four miles east-northeast to sec. 9, T. 12. R.5 E., these deposits of gravel and sand form plateaus a half mile to one mile wide, trending from west to east, elevated 820 to 850 feet above the sea and 40 to 60 or 75 feet above the adjoining low land, which on the north is a spruce and tamarack swamp about a mile wide and four miles long from east to west. Next to the north, these osars again rise in plateaus, ridges, and hills in sees. 19 to 22, T. 12, R. 5 E., enlminating in Griffith's Hill 'n the N. E. 1 of sec. 19, about 875 feet above the sea, or a little more can a hundred feet above the railway two miles distant on the west. This whole group of elevations is comnosed of gravel and sand, irregularly bedded, which appear to be denosits formed near the mouths of glacial rivers where they flowed between walls of ice and were here and there divided by ice islands. whose melting left these hills, ridges and plateaus bounded by moderately steep slopes and separated by intervening depressions. With Submergence the completion of the melting of the ice about and beneath these in Lake Agassiz. deposits, they sank to the bottom of Lake Agassiz, here about 500 feet deep; and the infrequent boulders that are found scattered upon their spriace were dropped from floating ice. Toward the north, west, and southwest, they are bounded by the flat plain of the Red River Valley, 750 to 760 feet above the sea; while toward the east and southeast they are connected with plains and undulating tracts of gravel and sand which reach with slow and gradual ascent to the Lake of the Woods and into Minnesota.

An instructive section of Bird's Hill has been made in the excavation Bird's Hill. of its gravel and sand for railway ballast. This massive osar extends from the railway station about one mile east-southeast and thence a half mile southeast, beyond which it is connected by a low ridge with the plateau of secs, 35 and 36, T. 11, R. 4 E. Its width is a quarter to a half of a mile; and its maximum height, one third to two thirds of a mile from the station, is 45 to 50 feet above the railway and the flat plain that extends thence west. The elevation of Bird's Hill station is 759 feet, and of the crest of this hill 805 to 810 feet above the sea. It has a broadly rounded top, with gentle slopes on all sides. Along its northern slope an excavation reaches three fourths of a mile, varying in width from ten to twenty-five rods and in depth from ten to thirty feet. The top of the excavation is about twenty feet below the crest of the kill. As thus exposed to view, the greater part of this deposit is seen to be gravel, much of which is very coarse, containing pebbles and rock fragments of all sizes up to one and a half feet in

Mass of till imbedded in torrential grave!.

diameter, many of the smaller being well rounded, but the larger mostly angular with only slight marks of water-wearing. In some portions near the west end of this section no interbedding of coarses and finer layers of the torrential osar gravel is noticeable for ten feet or more vertically, the spaces between the large stones and cobbles being filled with finer gravel and sand. Imbedded in this coarse gravel on the south side of the excavation I noted a mass of ordinary till, unstratified boulder-clay enclosing gravel and boulders in a solid matrix of somewhat sandy clay, wholly bounded by definite but irregular outlines, its dimension vertically being about ten feet and its length twenty feet. No other mass of till, either of small or large size, was observed in this entire section. It probably was derived from the drift that was contained within the ice-sheet and finally overspread its surface when the greater part of the thickness of the ice was melted From a sheet of drift thus deposited on the ice that formed the bank of the glacial river, this mass may have fallen into its channel. The eastern half of the section includes much fine gravel and sand irregg. larly interbedded, and along a considerable extent there the south side of the excavation from ten to twenty feet below its top is clear sand Palaozoic limestones make up about three quarters of the gravel, the remainder being Archean granites, gneiss and schists. Some two hundred boulders were found scattered upon the area of the excavation; and they occur with nearly the same frequency on other portions of this northern slope of the hill, but are rarely found on its top and southern slope. They vary in size from two to eight or ten feet in length; nearly all are Archean, but a few of Paleozoic limestone, un to five feet in length, were observed. None were seen enclosed within the gravel and sand of the osar; and the workmen informed me that they occur only on or near the surface. This hill was covered by Lake Agassiz, and its boulders were doubtless dropped or stranded from bergs and floes on this lake, before the border of the ice-sheet had retreated from the vicinity. Indeed, the occurrence of the boulders chiefly on the northern slope seems to indicate that they were mostly stranded there while ice yet remained beneath this deposit and prevented its entire submergence in the lake. The thickness of this osar is at least nearly 100 feet; for a well 45 feet deep, dug at the bottom of the excavation was wholly in the same formation of gravel and sand. It is thus known to extend considerably below the level of the Red River Valley plain, which consists of fluvial and lacustrine clay underlain at a slight depth by till. A section across the osar and plain would show till abutting upon the edge of the gravel and sand, indicat ing that both the stratified osar and the upper part of the till were formed from englacial drift.

Boulders dropped or stranded from floating ice

Thickness of this osar and its relation t the upper para of the till. HAM.

Smaller osar to twenty mile east of Rosser gravel and sa extends northw corner of sec. 1: westward throu rise ten to twe undulating surf the sea. Along the form and ch loulders. A sir from southeast Grosse Isle, a no township and in From the eas

Burns's Ridge, r

R.1E. Five m rilge was made Railway, which Winnipeg. The to twelve feet in A well in the le that is, sixteen for consists of strati at least as tar be visible width of itmay extend, p gravel, which is in diameter. No non the surface portions of this everal rods; but nits somewhat half miles, it o up to three or for o have been stra nclosing the osa he melting of the lake Agassiz to Only a small dep eet at the most, the underlying

but the larger ring. In some ling of coarser ble for ten feet nes and cobbles in this coarse ass of ordinary lders in a solid y definite but nt ten feet and small or large as derived from ally overspread ice was melted. ormed the bank channel, The nd sand irrega-

e the south side p is clear sand, the gravel, the sts. Some two of the excavan other portions on its top and t or ten feet in e limestone, up enclosed within formed me that was covered by ed or stranded ie ice-sheet had of the boulders ev were mostly leposit and preess of this osar r at the bottom of gravel and the level of the lacustrine clay oosar and plain d sand, indicat-

f the till were

Smaller osar deposits were observed in Ts. 12 and 13, R. 1 E., ten Osars to twenty miles northwest of Winnipeg. Beginning about three miles Winnipeg. east of Rosser, a narrow and occasionally interrupted belt of osar gavel and sand, with frequent boulders scattered on the surface, extends northwest diagonally across sees. 10, 16, and 20, the northeast corner of sec. 19, and the southwest part of sec. 30, T. 12, and thence westward through sec. 25 of the next township. Its highest portions rise ten to twenty-five feet above the depressions of the moderately midulating surface of till on each side, and are 800 to 810 feet above the sea. Along a distance of about a third of a mile in sec. 30 it has the form and character of an ordinary beach ridge and is destitute of builders. A similar low osar crosses sees, 12 and 14, T. 13, trending from southeast to northwest; and others occur in the vicinity of the Grosse Isle, a name applied to poplar groves in sees, 17 and 18 of this nownship and in secs. 12 and 13 of the next west.

From the east part of the Grosse Isle a notable osar, known as Burns's Ridge. Burns's Ridge, runs north-northwestward across secs. 30 and 31, T. 13. R.1E. Five miles west of Stonewall a section of this little beach-like rilge was made in sec. 30 by the original line of the Canadian Pacific Railway, which was abandoned for the more southern route by way of Winnipeg. The osar is cut to a depth of eight feet by the railway and to twelve feet in an excavation on the south side of the railway grade. A well in the lowest part of this excavation goes four feet deeper, that is, sixteen feet below the crest of the ridge. The entire section consists of stratified gravel and sand, extending eight feet above and at least as far below the general level of the adjoining surface, and the risible width of the deposit is about thirty rods. How much deeper itmay extend, perhaps with increasing width, is undetermined. Its gravel, which is nearly all limestone, contains pebbles up to six inches m diameter. No boulders occur in this excavation, and they are rare upon the surface of this and other such comparatively broad and high rtions of this osar, none being sometimes seen along a distance of everal rods; but in its narrower and slightly lower portions, as traced nits somewhat crooked course northward through the next one and half miles, it often is found to be sprinkled with frequent boulders up to three or four feet in diameter, mostly Archean. They appear Stranded whave been stranded as at Bi-Vs Hill, immediately after the ice-walls boulders. nclosing the osar were melted or even during that process, and before he melting of the ice under this gravel and sand allowed the water of lake Agassiz to submerge the more massive portions of the ridge, mly a small depth of water, probably not more than thirty or fifty let at the most, would be required for this; and afterward the melting I the underlying ice gave to the lake here a depth of fully 500 feet,

Farther to the north the osar sinks or is merged in the moderately undulating till which there forms the surface. The crest of this peculiar ridge, approximately 800 to 805 feet above the sea, undulates three to five feet within short distances, not showing so much uniformity in elevation and directness in its course as are characteristic of beach ridges; and it is the only instance observed in all my exploration of Lake Agassiz where a gravel formation nearly resembling a beach bears boulders on its surface. Not a single boulder has been anywhere found on or within the beaches of this lake; nor have osars like the Bird's Hill group or like these of smaller size and more stream. like courses been observed by me in any other part of this lacustrine area, excepting the vicinity of Red Lake in Minnesota. But osars doubtless exist here and there throughout the belt of modified drift that extends upon this area from Red Lake by the Lake of the Woods to Bird's Hill and Burns's Ridge; and probably they continue north northwesterly upon the country between Lake Winnipeg and Shoal Lake.

HISTORY OF LAKE AGASSIZ.

Drainage from the receding ice-sheet.

During the recession of the ice-sheets of both the earlier and later epochs of glaciation, drainage from the ice-border in many places flowed in channels from which the streams became turned by the slopes of the land into more northern courses when this was permitted by the farther retreat of the ice. Where the slope is southward, free drainage from the melting ice took place along the present valleys and these were partially filled with modified drift, remnants of which form terraces and plains on each side of the present streams. But on areas that sloped more or less directly toward the receding ice-horder. the streams of that time eroded channels which were abandoned when lower outlets were uncovered. Because of the large supply of water from the glacial melting, some of these river-courses became conspicuous topographic features, as noted by Dawson,* McConnell,† and Tyrrell t in various parts of the region between Lake Agassiz and the Rocky Mountains. On a slope nearly parallel with the retiring ioborder, the deserted river-courses were seldom the outlets of lakes of considerable size; but where a large area was inclined toward the ice-sheet, it was covered by an expanse of fresh water, formed by the streams that flowed down from the melting ice surface and overflowing across what is now a line of water-shed between great drainage basis,

Deserted river-courses. antil the cont charged by the largest of the

. F=4V.

largest of the
James, Souris,
outflowed east
Laurentian lak
United States of
levels than no
which they the

In tracing the the recession of stages of that real flows, Minness the stages of the and to note the west, whose on brought large deleposits of fine when the late

is southern por

ward to the Mc

labes, one of wh m central lowa. near Des Moines the first and c moraines of this the second or Gr Mineral Ridge i Antelope morair Mound in Hanco formed when th across the south Freeborn and Fa ing southern Le place of the ice. south end of the miles from its far rested on the cre

Report on the Geology and Resources of the region in the vicinity of the Forty-and Parallel, pp. 263-265; Geological Survey of Canada, Report of Progress for 1882-83-84, p.13-6
 Geological Survey of Canada, Annual Report, vol. i, for 1395, pp. 21 and 74 C.

[‡] Do., Annual Report, vol. ii, for 1886, pp. 43, 45 E, and 145, 146 E.

^{*} Changes of Leve June, 1888. Geol. Sur. the Fresh-water Glucin Contions, vol. xv. J pp 50-n5, with three m maps, Trans, of the Ge

he moderately crest of this sea, undulates so much unie characteristic all my exploray resembling a ulder has been nor have osars d more stream. this lacustrine ota. But osars ' modified drift e of the Woods continue north. ipeg and Shoal

earlier and later in many places turned by the s was permitted southward, free present valleys. nnants of which reams. But on ding ice-border. bandoned when supply of water es became con-McConnell,† and Agassiz and the he retiring iceitlets of lakes of ned toward the r, formed by the and overflowing drainage basis

until the continued recession of the ice allowed the lake to be discharged by the natural slope of the land. Lake Agassiz was the largest of these glacial lakes. Others existed in the basins of the Glocial lakes James, Souris, and Saskatchewan Rivers, of which the two last named one with Lake antilowed eastward into Lake Agassiz. The basins of the great Agassiz. Laurentian lakes, which are being studied by Mr. G. K. Gilbert of the United States Geological Survey, were also filled at this time to higher levels than now, determined by the elevations of the outlets through which they then flowed southward to the Mississippi and finally eastward to the Mohawk and Hudson.*

In tracing the history of Lake Agassiz it will be needful to review summary of the the recession of the ice-sheet which was its northern barrier, as the Agassiz. saves of that recession are shown by the successive terminal moraines flowa, Minnesota, South and North Dakota, and Manitoba; to observe the stages of the lake itself which are recorded in its successive beaches; and to note the contemporaneous history of the glacial lakes on the west, whose outflow by the Sheyenne, Pembina, and Assiniboine brought large deltas into the western edge of Lake Agassiz and spread leposits of fine silt over extensive areas of its bottom.

When the latest North American ice-sheet attained its greatest area, Recession of the is souther a portion from Lake Erie to North Dakota consisted of vast of the ice-sheet labes, one of which reached from central and western Minnesota south from Des Mones to the ocentral lowa. This Minnesota lobe in its maximum extent ended Leaf Hills. mear Des Moines, and its margin was marked by the Altamont moraine. the first and outermost in the series of eleven distinct marginal moraines of this epoch which are recognizable in Minnesota. When the second or Gary moraine was formed, it terminated on the south at Mineral Ridge in Boone County, Iowa. At the time of the third or Antelope moraine, it had farther retreated to Forest City and Pilot Mound in Hancock County, Iowa. The fourth or Kiester moraine was formed when the southern extremity of the ice-lobe had retreated across the south line of Minnesota and halted a few miles from it in Freeborn and Faribault Counties. The fifth or Elysian moraine, crossing southern Le Sueur County, Minnesota, marks the next haltingpace of the ice. At the time of formation of the fifth moraine, the with end of the ice-lobe had been melted back a hundred and eighty miles from its farthest extent, and its southwest side, which at first rested on the crest of the Coteau des Prairies, had retired thirty to

y of the Forty-table for 1882-83-84, p. 15 G d 74 C.

[&]quot; "Changes of Level of the Great Lakes," by G. K. Gilbert, in The Forum, vol. v, pp. 417-428. Jane, 1888. Geol. Sur. of Canada, Report of Progress to 1863, pp. 910-915. C. Whittlesey, "On the Fresh-water Glacial Drift of the Northwestern States," 1864, pp. 17-22, in Smithsonian Coninlutions, vol. xv. J. S. Newberry, in Report of the Geological Survey of Ohio, vol. ii, 1874, pp. 50-65, with three maps. "The Lake Age in Ohio," by E. W. Claypole, pp. 42, with four ags, Trans. of the Geol. Soc. of Edinburgh, 1887.

fifty miles to the east side of Big Stone Lake and the east part of Yellow Medicine County, Minn. During its next stage of retreat this ice-lobe was melted away from the whole of Le Sueur County, and its southeast extremity was withdrawn to Waconia in Carver County where it again halted, forming its sixth or Waconia morine. The seventh or Dovre moraine marks a pause in its recession when its southeast end rested on Kandiyohi County. Probably nearly all of the southern half of Minnesota was at this time divested of its ice. mantle, while nearly all of the northern half was still ice-covered. Be its next recessions the glacial border was withdrawn to the eighth or Fergus Falls moraine, and the ninth or Leaf Hills moraine. These are merged together in the prominent accumulations of the Leaf Hills. which lie in southern Otter Tail County, Minnesota, reaching in a semicircle from Fergus Falls to the southeast, east, and northeast a distance of about fifty miles, and marking the southern limits of this ice-lobe when it terminated half-way between the south and nor borders of Minnesota.* The south part of Lake Agassiz probably began to be uncovered by the retreating ice-sheet between its stages marked by the Waconia and Dovre moraines; and this lake reached northward from Lake Traverse 100 to 125 miles along the Red River Valley when the Fergus Falls and Leaf Hills moraines were accumu-

from its junction with the Minnesota lobe near the head of the the Coteau des Prairies, twenty-five miles west of Lake Traverse and Brown's Valley, at first reached about 200 miles south along the valler of the James or Dakota River to Yankton and the Missouri; but it was gradually diminished in its extent until, at the times of formation of the Kiester, Elysian, Waconia, and Dovre moraines, it no longer retained its lobate outline. While these moraines were being formed in Minnesota, the southwestern boundary of the ice-sheet in South and North Dakota passed from the vicinity of Big Stone Lake and Lake Traverse northwesterly along moraine belts that have been traced through Sargent, Ransom, Barnes, and Griggs Counties, North Dakota and by the sources of the James and Sheyenne Rivers. During the later stages represented by the Fergus Falls and Leaf Hills moraines the Dakota ice-front appears to have become again lobate, extending from the west shore of Lake Agassiz southward and then westward and northward, between the lake area and the Sheyenne River, to the prominent and typical moraines that are found south of Stump and Devil's Lakes, on the Big Butte, about Broken Bone Lake and north-

On the west side of Lake Agassiz the Dakota lobe of the ice-sheet

Recession of the ice-sheet in South and North Dakota from Yankton to the south side of Devil's Lake. ward, and on

these morainer seem to have I The course (Lake Agassiz, of the Lenf I morainic depor 17° 10', which abundance of b of the till form till which stret tuting the bed take this more but it has man; five feet or re gravel are plen the lacustrine occupies the ce

to Winnipeg.
Toward the southwest part dan now and o the way of the seems nearly co hat it probably northern portio
The Laurentian and overflowed
During the f

lake region at the Agassiz probabil Red Lake and the Bird's Hill grouth this boundary of course it seems strewn escarpm beyond to have North Dakota, to the north side the east part of part of the Tige. The eleventh

For detailed descriptions of these moraines, and of the recession of the ice-sheet in this Statesee Geology of Minnesota, vols. i and ii.

he east part of of retreat this County, and its Carver County. morine. The ossion when its y nearly all of sted of its ice. ec-covered. Be the eighth or ine. These are the Leaf Hills. reaching in a nd northeast, a n limits of this outh and norte gassiz probably ween its stages is lake reachel

the Red River

were accum-

if the ice-sheet to head of the e Traverse and dong the valler ouri; but it was of formation of s, it no longer re being formed et in South and Lake and Lake ve been traced , North Dakota rs. During the Hills moraines bate, extending then westward ne River, to the of Stump and Lake and north

ce-sheet in this State

ward, and on Turtle Mountain. In their remarkable development these moraines are similar to the massive Leaf Hills, with which they seem to have been contemporaneous.

The course of the ice front where it formed the northern barrier of Lake Agassiz, at the time of its accumulation of these great moraines of the Leaf Hills and the south side of Devil's Lake, is marked by morainic deposits both east and west of the lake near the latitude of 15° 10', which passes twenty miles north of Fargo; by an unusual Tract of till abundance of boulders near this latitude and farther north on portions of the till forming each side of the lacustrine area; and by a tract of Valley. till which stretches across the Red River Valley at Caledonia, constiunting the bed and banks of the river along the Goose Rapids. In the ake this morainic till was spread with a generally even surface, but it has many small inequalities, the higher portions being three to five feet or rarely ten feet above adjoining hollows. Boulders and gravel are plentiful on its surface, this being the only interruption of the lacustrine and alluvial clayey silt which elsewhere continuously occupies the central part of this valley plain from near Breckenridge to Winnipeg.

Toward the east the ice-sheet at this time had receded from the Eastward southwest part of Lake Superior, which was held about 500 feet higher course of the border than now and overflowed to the Saint Croix and Mississippi Rivers by the time of the the way of the Bois Brulé River and Upper Saint Croix Lake. It mornine. seems nearly certain also that the ice-border continued across Green Bay and the north part of Lake Michigan; and further east, I think that it probably crossed southwestern Ontario and the central or northern portions of New York, Vermont, New Hampshire, and Maine. The Laurentian lakes were dammed by the retreating glacial barrier and overflowed at the lowest points on their southern water-shed.

During the formation of the tenth or Itasea moraine, crossing the The Itasea lake region at the head of the Mississippi, the ice-sheet bounding Lake morning with Agassiz probably extended thence northward, passing not far west of that of the Tiger, Brandon, Red Lake and the Lake of the Woods, to the vicinity of Winnipeg, the and Arrow Bird's Hill group of osars being perhaps deposited at the angle where this boundary of the ice-sheet turned back southwestward. In that course it seems to have reached across the lake area to the boulderstrewn escarpment of the Pembina Mountain east of Thornhill, and evond to have passed south along the west shore of Lake Agassiz into North Dakota, to Pilot Knob in sec. 5, T. 154, R. 56, thence westward to the north side of Devil's Lake, and thence north northwestward by the east part of Turtle Mountain and along the moraine of the west part of the Tiger Hills and of the Brandon and Arrow Hills.

The eleventh or Mesabi moraine, well developed in northeastern

the accumulat Agassiz, excep delta, until its which probabl

due to diminis stream. Compared w

beach has a gra

a foot per mile. mouth of the la The mouth of t international be It is further fo Lake Agassiz t southern part of beaches that we tion of that are ever, was due to account of the ice-sheet, propo ing. As many recognizable by bined with a si 5, 10, 7, 15, 10, a Dakota and Mar the adjoining la porthward from

changes in the l table of the pres lake on its west the levels of Lak (a and aa) in th the Pembina Me well developed . northern limit of During the int

not sufficient for

In a later par

Minnesota, is probably represented by morainic accumulations north of Pokegama Falls of the Mississippi, about Bowstring Lake, the head of the Big Fork of Rainy River, east of the Narrows between the south and north parts of Red Lake, and on the east part of the Tiger Hills Lake Agassiz had contemporaneously a length of more than 300 miles from Lake Traverse to near the south end of Lake Winnipeg. Later moraines, formed at times of halt or re-advance, interrupting the recession of the ice-sheet between northern Minnesota and Hudson Bay. have not been determined; but I believe that they exist and await discovery when the glacial drift of that wooded and very scantily it. habited region shall be fully explored.

on the area of Lake Agassiz during the Herman beach.

The highest of the Herman beaches of Lake Agassiz extends in Min. Glacial molting nesota, as traced in this survey, to the north side of Maple Lake twenty miles east-southeast of Crookston, and probably it continues thence into the forest region on the east, where it is impracticable to follow its course, to the vicinity of Red Lake; and on the west side of Lake Agassiz it reaches through North Dakota and at least fourteen miles into Manitoba, terminating on the northern part of the Pembina escarpment somewhere between Thornhill and its northern end, that is, between fourteen and forty miles north of the international boulet ary. Before the formation of this beach was completed, the ice-sheet had retired from the lake area as far north as the beach extends. Dur ing pauses of this glacial recession the Dovre, Fergus Falls, Leaf Hills and Itasca moraines were formed, showing a northward retreat of the ice-border across a distance of about 150 miles in central Minnesota and 150 to 200 miles in North Dakota and southern Manitoba, with a maximum of probably not less than 300 miles in the Red River Valley where Lake Agassiz would doubtless cause a more rapid melting of the ice-margin. Through this time the River Warren eroded a change about fifty feet deep, approximately from 1,100 to 1,050 feet above the sea, or perhaps it eroded only the lower half of that depth, in the moerately undulating sheet of till which reached across the present valled of Lakes Traverse and Big Stone. The shortness of the time probably occupied in the formation of the beaches of Lake Agassiz may wel astonish us in what it implies concerning the rapidity of the recession of the ice-sheet, and the brevity, geologically speaking, of the stage of pause or re-advance when its moraines were accumulated,

> The retreat of the ice seems to have uncovered the southwest border of Lake Agassiz earlier than its shores farther north and on its east side, as is shown by the Milnor beach, a less distinct shore deposit that the Herman beach and 20 to 25 feet above it, which was observed near Milnor, North Dakota, and along a distance of about ten miles thence north-west to the Sheyenne, but was not recognized farther north nor

Southwestern shore near Milnor first uncovered from the ice.

ulations north Lake, the head ween the south he Tiger Hills than 300 miles. nnipeg. Later rupting the re-I Hudson Bay. exist and await ery scantily h.

extends in Mile of Maple Lake oly it continues npracticable to the west side of least fourteen of the Pembina thern end, that national bound. d, the ice-sheet extends. Im alls, Leaf Hills I retreat of the ntral Minnesota anitoba, with a ed River Valley d melting of the oded a channe O feet above the pth, in the mo. e present valley e time probably gassiz may wel of the recession , of the stage

lated. uthwest border nd on its east ore deposit than s observed near on miles thence rther north not in Minnesota. The formation of the Sheyenne delta had begun at this time of the Milnor beach, and continued through the time of the Herman beach, with which latter the Buffalo, Sand Hill, Pembina, and Assiniboine deltas were also contemporaneous. The departure of the ice from the Red River Valley seems to have been too rapid to permit the accumulation of definite shore deposits on the borders of Lake Agassiz, excepting the scanty Milnor beach derived from the Sheyenne delta, until its outlet was cut down to the level of the Herman beach. which probably represents a time of much slower erosion of the outlet, due to diminished glacial melting and smaller volume of the outflowing

Compared with the level of the present time, the highest Herman beach has a gradual ascent from south to north which averages nearly a foot per mile, amounting to about 175 feet in the 224 miles from the mouth of the lake at its southern end to the international boundary. The mouth of the lake was then about 1,055 feet, and its surface on the international boundary about 1,230 feet, above the present sea level. Northward It is further found that in the northern part of the explored area of Herman Lake Agassiz this upper or Herman beach, which is single along the southern part of the lake, becomes divided into numerous parallel leaches that were formed at intervals of pause in a progressing elevation of that area. A portion of these relative changes of level, however, was due to a subsidence of the lake itself toward the north, on account of the diminution of its attraction by gravitation toward the ice-sheet, proportionate with the decrease of the ice in its final melting. As many as six other Herman stages below the highest are recognizable by beach deposits, which indicate a rise of the land combined with a sinking of the lake to the amount successively of about \$ 10, 7, 15, 10, and 5 feet, or in total 55 feet, on the line between North bakota and Manitoba, while yet the relative elevations of the lake and the adjoining land along its southern part for some seventy-five miles porthward from Lake Traverse remained with only slight changes, not sufficient for the formation of any secondary beach ridge.

In a later part of this report the discussion of the causes of these changes in the height of the land and of the lake is accompanied by a table of the present elevations of the successive beaches formed by the lake on its west side through its entire existence, until it was drained to the levels of Lakes Manitoba and Winnipeg. The two highest beaches (a and aa) in the Herman series of this table were not found north of the Pembina Mountain escarpment; but the next two (b and bb) are well developed at Brandon and near Neepawa, reaching thus to the northern limit of my exploration at the south end of Riding Mountain. During the interval between these Herman beaches a and b, the

As soon as the

country had so

than the Rive

nerhaps flowing

Severn, and late

the Hill and Ha

eroded to a cons

laring the time

of the southeast

west of Hudson

Fossils have I

ommon species o

xtends at least to

as been collected

he later part of

ladstone beach be

oward the northe

he international |

Evidences of ma

he ice-sheet have

combined rise of the land and fall of the lake were only eighteen or twenty feet on the international boundary; but in this time the southern end of the ice-lobe west of the lake had been withdrawn from the east part of the Tiger Hills to Riding Mountain, and the Assiniboing delta was being rapidly deposited. The northward extent of Lake Agassiz in its subsequent Herman stages is not definitely determined north to Riding but evidently some of the upper beaches observed by Mr. Tyrrell on the foot slopes east of the escarpments of Riding and Duck Mountains belong to this series, the highest, according to information supplied by him, being in lat. 51°52' or two hundred miles north of the international boundary, at an elevation of about 1,460 feet above the sea.

Extent or Lake Agassiz in its Herman stages Mountains.

southward.

Later stages of from at least half of the area of Lake Agassiz during its Herman stages, the take while In the ensuing Norcross. Tintab Compacts The foregoing observations show that the ice-sheet was melted away through which the lake continued to outflow southward by the River Warren, the recession of the ice doubtless permitted it to extend north and east beyond Lake Winnipeg and along the lower valley of the Saskatchewan. Each of these stages is represented by two or three beaches in northern Minnesota and North Dakota and in southern Manitoba, which, with the seven beaches of the Herman series, make seventeen shore lines recognizable in that part of the lacustrine area belonging to the time of its southern outlet. Between the Herman and Norcross beaches the channel of the River Warren was eroded about 25 feet; it was deepened 15 to 30 feet more at the time of the Tintah beaches; 10 to 20 feet farther down to the Campbell beaches and again 10 to 20 feet to the McCauleyville beaches. In all, the mouth and southern end of the lake were lowered about 100 feet between the highest Herman beach and the lowest McCauleyville beach. Proceeding northward, the vertical distance between these beaches gradually increases to 240 feet on the international boundary. the difference of 140 feet more than the depression caused by erosion of the outlet being a "ributable to the northward rise of the land and subsidence of the water-level.

Before Lake Agassiz could obtain an outlet to the northeast, the thick ice-sheet that had filled the basin of Hudson Bay was so far melted as to admit the sea, which at first covered the land west of James Bay 350 to 500 feet above the present sea level. Eleven stages of Lake Agassiz are marked by beaches that lie below the beds of Lakes Stages of north-Traverse and Big Stone, which were the channel of the River Warren easternoutflow, when the lake ceased to outflow to the south. These beaches are separated by vertical intervals that vary from 10 to 45 feet through the range of elevation between the lowest McCauleyville beach and Lake Winnipeg, which was originally twenty feet higher than now,

the Nelson, the Winnipeg. The latitude of the so the present sea the Nelson betwchannel of the u localities. They district, occurrin to obtain sand for southwest of Ca feet above the common species beach, a half mi above the sea and considerable abur Uno lutcolus, Lar Lam., and Gyrau were kindly dete This luteolus is o the genus, its rang York, and west to Both these species take of the Woo

ly eighteen or this time the ithdrawn from he Assiniboine extent of Lake ly determined. Mr. Tyrrell on uck Mountains on supplied by o international sea.

as melted awar Herman stages. lleyville stages, d by the River to extend north r valley of the y two or three nd in southern an series, make lacustrine area on the Herman ren was eroded the time of the mpbell beaches es. In all, the about 100 feet t McCauleyville between these ional boundary. ed by erosion o

northeast, the Bay was so far d west of James stuges of Lake bods of Lakes River Warren ese beaches are 15 feet through ville beach and gher than now.

of the land and

As soon as the ice upon Hudson and James Bays and the adjoining country had so receded as to give to Lake Agassiz an outlet lower than the River Warren, it began to be drained in that direction, nerhaps flowing at first across the water-shed between the Poplar and severn, and later along lower courses, including the canoe route by the Hill and Hayes Rivers. Each of its successive outlets was probably ended to a considerable depth, being occupied by the outflowing river laring the time of formation of two or more beaches, until the retreat of the southeastern border of the portion of the ice-sheet remaining west of Hudson Bay finally permitted drainage to take the course of the Nelson, the ice-dammed Lake Agassiz being thus changed to Lake Winnineg. The northeastern outflow commenced when the lake at the latitude of the south end of Lake Winnipeg stood about 1,000 feet above the present sea level, and it was gradually lowered to 730 feet when the Nelson between its successive lakes began to erode the shallow channel of the upper part of its course.

Fossils have been found in the deposits of Lake Agassiz at two calities. They are all fresh-water shells of species now living in this district, occurring in beach ridges where excavations have been made mobtain sand for masons' use. The Campbell beach, about six miles southwest of Campbell, Minnesota, at an elevation approximately 985 Molluscan feet above the sea, has thus yielded shells of Unio ellipsis, Lea, a fauna of Lake rommon species of the upper Mississippi region. In the Gladstone beach, a half mile northeast of Gladstone, Manitoba, about 875 feet above the sea and 165 feet above Lake Winnipeg, four species occur in considerable abundance from two to four feet below the surface, namely, This luteolus, Lamarck, Spherium striatinum, Lam., Spherium sulcatum, lam, and Gyraulus parvus, Say, These species from both localities were kindly determined by Prof. R. Ellsworth Call, who states that Two luteobus is one of the most widely distributed representatives of he genus, its range being from Lake Winnipeg to Texas, east to New York, and west to Montana. It is generally abundant in Minnesotaboth these species of Sphærium are reported by Dr. Dawson from the take of the Woods and Pembina River; and the first is the most ommon species of its genus in Minnesota, while its range northward stends at least to Great Playgreen Lake and York Factory, where it as been collected by Dr. Bell. The Campbell beach was formed in lelater part of the time of the lake's southward outflow; and the ladstone beach belongs to the middle portion of the time of its outflow ward the northeast, its south end being then about 85 miles south of he international boundary.

Evidences of man's presence in this region during the departure of heice-sheet have been discovered by Miss Franc E. Babbitt at Little

Falls in central Minnesota. A stratum containing many artificially chipped fragments of quartz is enclosed there in the modified drift of the upper Mississippi Valley, which was deposited by the floods supplied from the melting ice-sheet in its retreat while it was being withdraw, from northern Minnesota and the Red River Valley.* It seems probable therefore that men lived on the shores of Lake Agassiz and witnessed the erosion of the channel of the River Warren, the gradual lowering of the lake level and reduction of its area, and its later north-castward cutflow to Hudson Bay. But this is not left wholly be conjectured by Mr. Tyrrell informs me that in northwestern Manitoka, at an elevation of 1,135 feet above the sea, he has found sharp-edgel

fragments of quartzite, chipped by human workmanship, interbedder

with the rounded gravel of one of the Campbell beaches.†

Traces of men contemporancous with the glacial recession and Lake Agassiz.

> If the question be asked how many thousand years ago did the recession of the ice-sheet take place, causing Lake Agassiz to fill the Red River Valley and the basin of Lake Winnipeg, a reply is furnished by the computations of Prof. N. H. Winchell, that approximately 8,000 years have elapsed during the crosion of the postglacial gorge of the Mississippi from Fort Snelling to the Falls of Saint Anthony: Dr. Andrews, || that the erosion of the shores of Lake Michigan, and the resulting accumulation of dune sand drifted to the southern end of the lake, cannot have occupied more than 7,500 years; of Professor Wrights that streams tributary to Lake Eric have taken a similar length. time to cut their valleys and the gorges below their water-falls; of M Gilbert,** that the gorge below Niagara Falls has required only 7.000 years or less; and of Prof. B. K. Emerson, it on the rate of deposition of modified drift in the Connecticut Valley at Northampton, Massac chusetts, from which he believes that not more than 10,000 years had clapsed since the glacial period. An equally small estimate is also

Measurements of time since the last glacial epoch. indicated by
the last great
of time, surpr
with the peri
long record or
the last glacia
Mississippi, of

The entire at the most n this time may of its beaches concurrent sul amounted toge Mountain and estimates may with those of their north an have suffered a time which ver the shores of L them being sur similarly great about its south contrast indeed recession of the Nelson River, 1 vears.

Before Lake
Dakota ice-lobe
part of the are
Minnesota ice-le
the set was fort
Earth and Min
Slough to the E
this lake proba
Stone Lake, wit
Counties, attain
tontinued glacia
the Cannon Riv.
covered the lowe

Proceedings of Am. Assoc, for Adv. of Science, vol. xxxii, 1886, pp. 385-390. American Naturalist, vol. xxiii, pp. 594-605, and 607-708, June and July, 1884; and Proc., Bostor S Natural History, vol. xxiii, 1888, pp. 421-449.

[†] Preliminary notes of this discovery, and of the northwestward continuation of the beast. Lake Agassiz in the district of Riding and Duck Mountains, are included by Mr. Tyrrepaper, "On the Superficial Geology of the Central Plateau of Northwestern Canada," realled the Geological Society of London, Nov. 7, 1888, of which an abstract is given in the Geol g Magazine, III, vol. vi, pp. 37-38, Jan., 1889.

[‡] Geology of Minnesota, Fifth annual report, for 1876; and Final report, vol. ii, pp. 3384. Quart, Jour. Geol. Soc., vol. xxxiv, 1878, pp. 886-901.

Quart, Jour. Geol. Soc., vol. xxxiv, 1878, pp. 886-901.

Transactions of the Chicago Academy of Sciences, vol. ii. James C. Southall's Epoca Co.

Mammoth and the Apparition of Man upon the Earth, 1878, chapters xxii and xxiii.
§ Am. Jour. Sci., III., vol. xxi, pp. 129-123, Feb., 1881: The Ice Age in North America. Section 18, 1881.

^{**} Proceedings, Am. Assoc. for Adv. of Science, vol. xxxv., for 1856, p. 222. "The Historyd the Ningara River," Sixth An. Rep. of Commissioners of the State Reservation at Ningara for 1899, pp. 61-84.

^{††} Am. Jour. Sci., III., vol. xxxiv, pp. 404-5, Nov., 1897.

^{*}U.S. Geological St

^{&#}x27;U.S. Geological St

ny artificially odified drift or floods supplied ng withdraw v. * It seems e Agassiz and en, the grabual its later north. left wholly to tern Manitoba, nd sharp-edget ip, interbedde:

5.4

rs ago did the assiz to fill the oly is furnished approximately glacial gorge of at Anthony: ichigan, and the hern end of that ofessor Wrights milar length. ter-falls; of Mr nired only 7.00 te of deposition ampton, Massa 0.000 years have

385-390 , \tuer Proc., Boston 8

estimate is al-

tion of the beach Canada," read beter ven in the Ged 2

rt, vol. ii, pp. 313/4. uthall's Epand xxiiic North America. '"

22. " The History ervation at Niagan indicated by the studies of Gilbert * and Russell † for the time since the last great rise of Lakes Bonneville and Lahontan. These measures of time, surprisingly short whether we compare them on the one hand with the period of authentic human history or on the other with the long record of geology, carry us back to the date when the ice-sheet of the last glacial epoch was melting away from the basins of the upper Mississippi, of the Red River of the North, and of the Laurentian lakes.

The entire departure of this ice-sheet therefore probably occupied Duration of at the most not more than two or three thousand years; and half of Lake Agassi this time may measure the duration of Lake Agassiz, with the formation that of Lake of its beaches marking more than twenty-five successive stages in the indicated by concurrent subsidence of its surface and rise of the earth's crust, which and beach amounted together to 700 feet on the latitude of the north part of Duck Mountain and the middle of Lake Vinnipeg. But even these short estimates may be too long. The shores of Lake Michigan, similar with those of Lake Agassiz in the drift of which they are formed, in their north and south trends, and in the adjoining depths of water, have suffered an amount of erosion by the lake waves during postglacial time which very far exceeds the total erosion that was effected upon the shores of Lake Agassiz during all its stages, the proportion between them being surely not less than ten to one; and Lake Michigan has a similarly greater amount of beach deposits, which upon a large area about its south end are raised by the wind in conspicuous dunes. This contrast indeed suggests that the duration of Lake Agassiz, and the eression of the ice-sheet from Lake Traverse to the lower part of the Yelson River, may have been included within less than one thousand

Before Lake Agassiz began to exist, the receding Minnesota and Dakota ice-lobes had each given place to a large lake on the central part of the area from which they withdrew. By the barrier of the Minnesota ice-lobe a lake having an elevation of about 1,150 feet above Glacial lake in the sea was formed in southern Minnesota in the basin of the Blue the basin of the Earth and Minnesota rivers, outflowing southward by way of Union Minnesota Slough to the East Fork of the Des Moines. In its maximum extent this lake probably had a length of 160 miles, from Waseca to Big Stone Lake, with a width of forty miles in Blue Earth and Faribault Counties, attaining an area of more than 3,000 square miles. The continued glacial recession afterward opened lower outlets eastward to the Cannon River, and at the time of the Waconia moraine had uncovered the lower part of the Minnesota Valley, permitting the lake to

[·] U.S. Geological Survey, Second annual report, p. 188.

U.S. Geological Survey, Monograph XI, Geological History of Lake Lahontan, p. 273.

be wholly drained northeastward to the Mississippi.*

Modified drift of the Minnesota Valley.

The modified drift from the retreating ice on the upper anesota basin was deposited along the lower half of this valley, filling it with stratified gravel, sand and clay, to a depth 75 to 150 feet above the present river from New Ulm to its mouth, which shows that at least this portion of the valley was excavated in the sheet of till during the interglacial epoch, and remained with nearly its present form through the later glaciation. It seems also probable that the upper part of the channel above New Ulm, occupied by the River Warren at the time of the Herman beaches, remained from such interglacial erosion, so that the first outflow from Lake Agassiz was at a level some twenty-five feet below the general surface adjoining Lakes Traverse and Big Stone and Brown's Valley, being thus approximately marked by the Milnor beach. † As long as streams poured into this valley directly from the melting ice-sheet, its modified drift, gathered from the ice in which it had been held, continued to increase in depth; but when the ice had retreated beyond the limits of the Minnesota basin, the water discharged here from Lake Agassiz brought no modified drift, and was consequently a most powerful eroding agent. By this River Warren the valley drift, so recently deposited, was mostly swept away, and the channel was excavated to a depth lower than the present river. But since Lake Agassiz began to outflow northeastward, the Minnesota Valley and that of the Mississippi below, carrying only a small fraction of their former volume of water, have become considerably filled by the alluvial gravel, sand, clay and silt, which have been brought in by tributaries, being spread for the most part somewhat evenly along these valleys by their floods, ‡

Prof. J. E. Todd supplies me the approximate outline of a lake named by him Lake Dakota, which occupied the valley of the James or Dakota River contemporaneously with the foregoing, reaching from Mitchell 170 miles north to Oakes and varying from 10 to 30 miles in width. It outflowed southward by the present course of the James to the Missouri. The Dakota ice-lobe, which had filled this valley and in its recession formed the northern shore of Lake Dakota, was not therefore the cause of this lake in the same way that the lake in the Blue Earth and Minnesota basin and Lake Agassiz owed their

Lake Dakota, outflowing southward to the Missouri River.

Erosion by the

existence to t Dakota has a feet below o glacial recess height of abo south to nort Todd states t part, from Mi ward is sand eastern border The outflow

retreat of the northern part eastward into by the further des Prairies an tract of the sa glacial lake fo Dovre morain stream of the and enters the tion of the wat River would flo the general le present level o branch of the feet above the beds in the vic waves have act undulating till highest shore 1.345 feet abo expanse of wat depth of the ch before the glad Agassiz, indica Valley had gai already drained the Red River It is evident, experienced on direction from James River V

^{*} Geology of Minnesota, vol. i, pp. 460, 622, 542,

[†] Compare with Geology of Minnesota, vol. i, pp. 479-485, describing the chains of takes Martin County, Minnesota, which are apparently due to interglacial water-courses that were not wholly filled with drift in the last glacial epoch.

the Minnesota Valley in the Ice Age," Proc. Am. Assoc. for Adv. of Science, vol. xxxii. 1883, pp. 213-231; also in Am. Jour. Sci., III. vol. xxvii, Jan. and Feb., 1884.

This take is partially mapped by Prof. Todd in Proc. Am. Assoc. for Adv. of Science. vol. XXXIII, 1884, p. 393.

The modified basin was deith stratified the present at least this ring the interthrough the er part of the at the time ial erosion, so ne twenty-five and Big Stone by the Milnor ectly from the ce in which it n the ice had he water disdrift, and was River Warren ept away, and present river. the Minnesota small fraction

f a lake named the James or reaching from 10 to 30 miles course of the had filled this Lake Dakota, that the lake siz owed their

ly filled by the

ght in by tribu-

ly along these

existence to the barrier of the ice-sheet in its retreat. The bed of Lake Dakota has a nearly uniform elevation of 1,300 feet, or is within ten fact below or above this, throughout its length; and during the glacial recession it was covered by a lake whose shores have now a height of about 1,300 to 1,350 feet, probably ascending slightly from south to north, as compared with the present sea level. Professor Todd states that the surface of this lacustrine area in its southern part, from Mitchell to Redfield, is nearly flat till, but thence northward is sand and less-like silt, while considerable tracts of the eastern border of its north part consist of low dunes.

The outflowing James River was cutting down its channel during the retreat of the ice-lobe, and its erosion was so rapid as to prevent the northern part of Lake Dakota from retaining sufficient depth to outflow eastward into the south end of Lake Agassiz when the way was opened by the further departure of the ice, receding from the Head of the Coteau des Prairies and beginning to uncover the Red Rive: Valley. A large tract of the sand and silt beds of Lake Dakota, and of a contiguous glacial lake formed in Sargent County, North Dakota, at the time of the Dovre moraine, now sends its drainage to the Red River by the head stream of the Wild Rice, which passes north of the Head of the Coteau and enters the area of Lake Agassiz near Wyndmere. The lowest portion of the water-shed on this lacustrine deposit, over which the James River would flow east to the Wild Rice River is scarcely ten feet above the general level of the James Valley or twenty-five feet above the present level of the James River, being at Amherst on the Aberdeen branch of the Saint Paul, Minneapolis and Manitoba Railway, 1,312 feet above the sea. The elevation of the upper portion of the lake beds in the vicinity of Oakes, and the lack of evidence that the lake waves have acted at any greater height upon the adjoining surfaces of andulating till and morainic hills, lead to the conclusion that the highest shore line of the north end of Lake Dakota is not more than Less change of 1345 feet above the sea, showing that there was only a shallow area of Lake expanse of water above the plain of lacustrine silt. On the north the l. ke Agassiz, depth of the channel of the inflowing James River, eroded apparently parture of the before the glacial retreat could permit an eastward outlet into Lake Agassiz, indicates that the surfaces of land and water in the James Valley had gained nearly their present relations, Lake Dakota being already drained away, when the Wild Rice River and the south end of the Red River Valley were uncovered by the recession of the ice-sheet. It is evident, therefore, that the long area of Lake Dakota has experienced only slight differential changes of level, at least in the direction from south to north, since the departure of the ice. The James River Valley is thus strongly contrasted with the northward

chains of jakeources that were no

Science, vol. xxx

dv. of Science, vo

uplifting that has affected the Red River Valley as shown by the beaches of Lake Agassiz, the highest of which rises from south to north about six inches per mile for 30 or 40 miles at its south end, but a foot or more per mile within 40 miles farther north, and indeed has an average north. ward ascent of about one foot per mile through an extent of 400 miles along the west side of this lake in North Dakota and Manitoba,

As Lake Agassiz gradually extended to the north, following the receding ice-barrier, it received successively by three outlets the drainage of the glacial lakes of the Saskatchewan and Souris basins These streams took the course of the Sheyenne, Pembina, and Assini. boine Rivers, each bringing an extensive delta deposit. With the first retreat of the ice from the Missouri Coteau a glacial lake began to exist in the valley of the South Saskatchewan in the vicinity of the Elbow. probably outflowing at an early time by the way of Moose Jaw Creek. and through a glacial lake in the upper Souris basin, to the Missouri near Fort Stevenson. Later the outflow from the Lake Saskatchewan may have passed to the Lake Souris by way of the Wascana River, after passing through a glacial lake which probably extended from Regime sixty miles to the west in the upper Qu'Appelle basin. When the Dakota ice-lobe was melted back to the vicinity of Devil's Lake, the drainage of Lake Souris passed southeast by the Big Coulée, one of the head streams of the Sheyenne, flowing thence for some time southward by the James River to Lake Dakota, but later eastward and southward by the Sheyenne into Lake Agassiz. A manuscript report of a reconnoissance in North Dakota by Major W. J. Twining, in 1869, describes the valley of the Big Coulée as 125 feet deep and a third of a mile wide enclosing several shallow lakes along its course. "This great valley, he writes, "preserves its character to within twelve miles of the Mosses [Souris] River, and connects through the clay and sand ridge with the open valley of that stream."

The Shevenne delta, reaching from the Lightning's Nest fifty miles northwest to the south bend of the Maple River, and having a maximum width of nearly thirty miles to the northeast from the south bend of th-Sheyenne, probably covers an area of 800 square miles to an averagdepth of 40 feet. A large portion of this delta is doubtless modate: The Sheyenne drift, which was brought down by gracial streams from the delta formed party of modilisurface of the ice-sheet, their coarser gravel with much sand being field drift, and deposited in the high plains that slope southward along the outer size allowium from of the great moraines that pass south of Devil's Lake, their finer gravel and sand being carried by the Sheyenne to this delta, and their finest silt and clay being spread in the quiet water of the lake over a much larger adjoining area of its bed, from near Breckenridge northward beyond the mouth of the Sheyenne. Much alluvium was also supplied

Lakes of the Saskatchewan and Souris, outflowing to Lake Agassiz by the Sheyenne.

Big Coulée.

Sheyenne Valley.

from the erosi Coulée, probat in depth along sheet, mainly shales. The v according to t delta, or perha sediments that of the Sheyenr valley. It was then was erode interglacial tir with till in the

degree its troug

are of the Min

delta would be

When the be

water of the r which the Red of water, whiel their fine claye; Agassiz by its d Pembina, and A spread over lar at a surface · rmations, mue Irainage of the strace, whethe guishable from those now living 1 Lake Agassiz the present mar and logs of wood food. Thus the beis at McCaule at 7 and 20 f many fragments Glyndon, Minne other observatio River Valley in dained away, ar flow by the riv deposited.* Ev

- Geology of Minn

by the beaches to north about a foot or more average north. t of 400 miles unitoba, following the

e outlets the Souris basins na, and Assini With the first began to exist of the Elbow. ose Jaw Creek. the Missour Saskatchewa. na River, after I from Regina in. When the vil's Lake, the ulée, one of the ime southward and southward ort of a recor-1869, describes of a mile wide great valley,

lest fifty miles ng a maximu: ith bend of the to an average btless modifier m the melting ch sand being the outer sim eir finer gravel and their tines e over a much ige northward s also supplied

s of the Mous

ridge with the

from the erosion of the Sheyenne Valley, which, with that of the Big Coulée, probably averages three fourths of a mile in width and 150 feet in depth along a distance of 200 miles. This channel is cut in the drift sheet, mainly till, and in the underlying easily eroded Cretaceous shales. The volume of the material supplied from it would be equal, according to these estimates, to about three fourths of the Sheyenne delta, or perhaps to three eighths of both the delta and the finer clayey sediments that were deposited farther out in the lake. But the valley of the Sheyenne was doubtless also both a preglacial and an interglacial valley. It was probably wholly filled with till in the first glacial epoch, then was eroded, chiefly in this drift, to nearly its present size during interglacial time, and was partially but perhaps not wholly refilled with till in the last epoch of glaciation. If it retained in considerable degree its trough-like form beneath the last ice-sheet, as was evidently Tie of the Minnesota Valley, its erosion and its tribute to the Sheyenne delta would be less than the proportion estimated.

When the bed of Lake Agassiz was gradually uncovered from the water of the receding lake, some parts of its central plain through which the Red River flows probably remained as broad shallow basins f water, which that river and its tributaries have since filled with their fine clayey alluvium. The similar clayey sift brought into Lake Agassiz by its delta-forming affluents, the Buffalo, Sand Hill, Sheyenne, deposited along Pembina, and Assimboine Rivers, and others farther north, had been of the Red spread over large areas of the lake bed, but more extensive portions after the at a surface of till, with no such lacustrine deposit. Over these draining of Lake Agassiz. simations, much alluvium has been laid down along the avenues of gainage of the old lake bed, and it has filled depressions of the original surface, whether of lacustrine sediments or of till, being only distinguishable from the former by its containing in some places shells like se now living in the shallow lakes of the country adjoining the area Hake Agassiz, remains of rushes and sedges and peaty deposits, as of the present marshes of the Red River Valley, and occasional branches and logs of wood, such as are floated down by streams in their stages of Hol. Thus the occurrence of shells, rushes and sedges in these alluvial leds at McCauleyville, Minnesota, 32 and 45 feet below the surface, or about 7 and 20 feet below the level of the Red River, of sheets of turf, many fragments of decaying wood, and a log a foot in diameter at Gyndon, Minnesota, 13 to 35 feet below the surface, and numerous ther observations of remains of vegetation elsewhere along the Red River Valley in these beds, demonstrate that Lake Agass'z had been sained away, and that the valley was a land surface, subject to overfor by the river at its stages of flood when these remains were apposited.* Even at the present time much of the area of stratified

Geology of Minnesota, vol. ii, pp. 529, 530, 663-4, and 668-9,

clay that almost continuously forms the central part of the valley plain is covered by the highest floods, and probably no portion of it is more than ten feet above the high water line of the Red River and it tributaries. The position of the thick beds of fine silt and clay in the central depression of the Red River Valley shows that they were not mainly deposited by the waters of Lake Agassiz, which must have spread them somewhat equally over both the lower and higher parts of the lacustrine area; but instead appears to prove that at least their upper and greater part was brought by the rivers which flowed into this hollow and along it northward after the glacial lake was withdrawn

BEACHES AND DELTAS.

Size and

A brief general description of the beach ridges of Lake Agassiz has material of the been given on page 12 E, their usual height being there stated to be from three to ten feet above the adjoining land on the side that was away from the lake, and ten to twenty feet above the adjoining land on the side where the lake lay, their varying breadth between the bases of the slopes being from ten to thirty rods. The beach ridge is thus; broad wave-like swell, with a smooth gracefully rounded surface Like the shore accumulations of present lakes and of the sea coast these of Lake Agassiz vary considerably in size, having in any distance of five miles some portions five or ten feet higher than others, due to the unequal power of waves and currents at these parts of the shore. The usually moderate slope of the land toward Lake Agassiz was favorable for the formation of beach ridges, and they occur at many successive levels, marking pauses in the gradual elevation of the land and subsidence of the lake. The highest distinct beach ridge of Lake Agassiz has been traced in a continuous course along a distance of more than four hundred miles in Minnesota, South and North Dakota, and Manitoba. In calling it continuous, I mean to say that whenever interrupted, as through its having been carried away by streams of where portions of the lake shore received no beach deposits, it is found a little distance farther along, beginning again at very nearly the same height. Commonly the land upon each side of the beach ridges of Lake Agassiz is till or unstratified clay, containing some intermixture of sand and gravel and occasional stones and boulders. The material of the beach ridge is remarkably in contrast with this adjoining and underlying till, for it includes no clay, but consists of stratified said and gravel, the largest pebbles being usually from two or three to six inches in diameter.

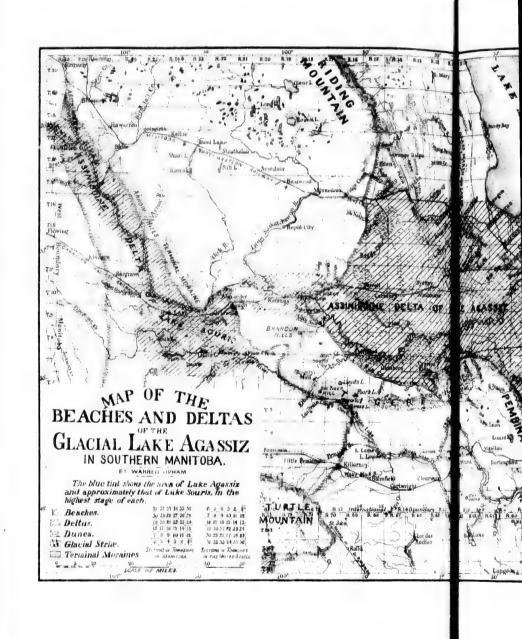
Their formaaction.

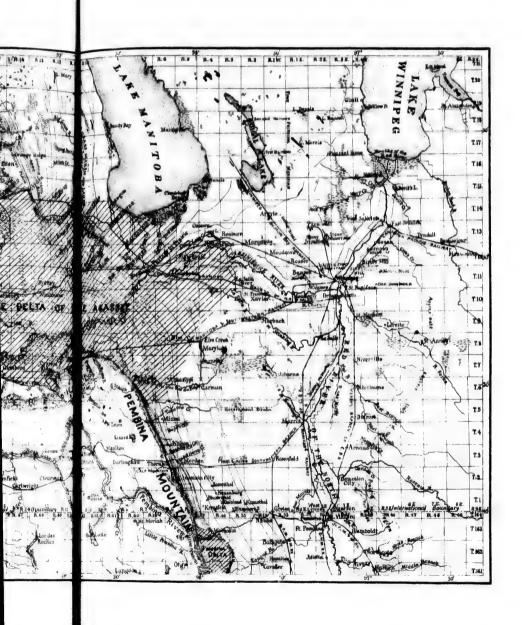
The action of the waves gathered from the deposit of till, which was the lake bed, the gravel and sand of its beaches; and corresponding of the vailey plain tion of it is more ed River and it it and clay in the sat they were not which must have ad higher parts of that at least their chich flowed into e was withdra.vn.

Take Agassiz has there stated to he side that was djoining land on veen the bases of ridge is thus a ounded surface, of the sea coast. in any distance in others, due to rts of the shore, ke Agassiz was z occur at many tion of the land h ridge of Lake listance of more rth Dakota, and that whenever by streams of osits, it is found nearly the same beach ridges of

till, which was corresponding

The material sadjoining and stratified sand or three to six





deposits of stratified clay, derived from the same erosion of the till. sank in the deeper part of the lake. But these sediments were evidently of small amount and are not noticeable upon the greater part of this lacustrine area, which consists of a smoothed sheet of till. Where the beaches cross delta deposits, especially the fine silt and clay that lie in ment of the delta gravel and sand, they are indistinctly developed or all entirely. On the other hand, the most massive and typical lavelopment of beach ridges is found on areas of till that rise with a gentle slope of ten or fifteen feet per mile. No boulders referable to Absence of transportation by floating ice have been found within or upon any of boulders. the beach deposits of this lake.

When Lake Agassiz formed its first and upper beach, its outlet was The upper or don't 85 feet above the present surface of Lake Traverse, or 1,055 feet Herman beach, have the sea. The channel which at this time had been excavated in he drift by its outflow was 40 to 50 feet deep along the distance of built fifty miles, where are now Lake Traverse, Brown's Valley, and g Stone Lake. This beach is crossed by the Breckenridge line of le Saint Paul, Minneapolis & Manitoba Railway at a point about one and a half miles northwest of Herman, Minnesota, from which place it denominated the Herman beach.

At the next epoch after that of the upper or Herman beach, when Norerossbeach. he lake level in its southern part was again nearly stationary long nough to form a ridge of gravel and sand upon its shore, the outlet ed been eroded about 25 feet deeper than at the time of the upper ach, but was still 60 feet above the present Lake Traverse and rown's Valley. The beach of Lake Agassiz, when it had this lower rel is crossed by the Breckenridge railway line at Norcross, innesota, five miles northwest of Herman; and it is therefore named le Norcross beach.

The next two series of beach deposits were formed when the outlet Lake Agassiz had been lowered respectively, for the first, 15 to 30 Tantah and et and for the second, 40 to 50 feet below its level at the time of the orcross beach. These beaches take their names from Tintah and ampbell, Minnesota, the next two stations northwest of Norcross on e Breckenridge railway line.

The fifth and lowest beach of Lake Agassiz, while it outflowed to the McCauleyville ath, was formed after a further erosion of 20 feet, lowering the outlet beach. 960 feet above the sea, and completing the exeavation of its channel the present beds of Traverse and Big Stone Lakes. My first obsertion of this beach was three and a half miles northeast of McCauleyle Minnesota, about tifteen miles north of Breckenridge. It is erefore named the McCauleyville beach. Five distinct series of ach ridges of gravel and sand were thus formed by Lake Agassiz at

successive stages of height during its process of deepening the channel by which it outflowed southward.

Northward ascent and subdivision of these beaches. Tracing these beaches to the north, they are found to have a gradual ascent in that direction, diminishing in amount from the highest and earliest to the lowest and latest; and the single beach ridges of the south part of the lake are found to be represented northward by two of three or several parallel beaches. Accordingly, in the following descriptions of the beach ridges observed in Manitoba, those are grouped together which seem to represent the stages of the lake that southward were combined respectively in the Herman, Norcross, Tintah, Campbell and McCauleyville beaches. The Herman beach at the north is thus more or less clearly subdivided into seven, the Norcross and Tintah beaches each become double, and the Campbell and McCauleyville beaches each become threefold; so that seventeen stages are recorded in the elevation of the northern part of the area of Lake Agassiz and in the northward subsidence of the water level, belonging to the period of outflow southward by the River Warren.

Beaches formed while Lake Agassiz outflowed northeastward.

Eleven lower beaches were formed while Lake Agassiz outflowed; Hudson Bay; and these are named from localities in North Dakota and Manitoba. The first three are called the Blanchard beaches, and the next three are successively the Hillsboro, Emerado, and Ojata beaches, from towns in North Dakota near which they are veldeveloped; while the remaining five receive their names from Manitoba, being in descending order the Gladstone, Burnside, Ossowa, Stonewall and Niverville beaches. The rate of their northward ascent is ody about a sixth or an eighth as much as that of the first Herman beach. In all these stages, excepting the lowest one when the Niverville beach was formed, Lake Agassiz extended south of the international boundary.

BEACHES OF THE HERMAN STAGES.

In T. 1, R. 5.

The west shore of Lake Agassiz enters Manitoba two miles west fitne east line of range five, at a distance of thirty-six miles from the Red River. On the international boundary and for the next ten miles northward the shores of the highest stages of the lake were on the steep wooded escarpment of the Pembina Mountain, the base of which here is 1,100 to 1,150 feet above the sea, rising slightly northward, and the verge of its top 1,300 to 1,400 feet. This ascent, forming the step face of the Pembina Mountain, is made upon a width of about a quarter of a mile.

Where the Pembina Mountain plateau is ascended by the Soutwestern Branch of the Canadian Pacific Railway, and for a distance about four miles south and two miles north of this railway, is

hiefly prairie. are well develope examination of t in the south edg massive rounded liteen feet in a di is crest, which with similar out wilt on its crest. alse of the N.W. andulating surface be beach is inter r Cheval Creek. Rewen's house. vest of Mr. Bowe readly than usua hirty rods, border wenty rods, and each is gravel and gures also a thir 3, R. 6, where it e elevation of it est is reduced to wer beach ridges and to consist of three inches in d agnesian limestor e Pembina Moun chean rocks. T stpart of sees. 16 earpment of Pem at thirty miles no

at it is the cont

aches in Minneson

About a quarter o

een to twenty fee

me's house, next

we the sea. It t

hth of a mile to t

ofeet or in part

wel reaches west

dfrom Morden to

mineipal line of

ng the channel

have a gradual he highest and a ridges of the ward by two or the following ose are grouped that southward , Tintah, Campat the north is Norcross and and McCauley. teen stages ale o area of Lake

ssiz outflowed to n North Dakota ard beaches, and erado, and Oias, h they are well es from Manitola, ssowa, Stonewall d ascent is e.; t Herman beach. Niverville beach ational boundars.

level, belonging

stpart of sees. 16 and 21, T. 3, R. 6, and in sec. 28 comes to the steep arpment of Pembina Mountain, with which it coincides along the wo miles west of at thirty miles north-northwest. The elevation of this beach shows miles from the ie next ten mie at it is the continuation of the highest in the series of Herman he base of which

v northward, and orming the step f about a quarter

d by the Sout for a distance his railway.

mincipal line of escarpment is replaced by a moderate slope which is bliefly prairie. Across this tract the Herman beaches of Lake Agassiz me well developed. In order proceeding northward, the first point of emination of the highest beach was near William II. Oakley's house in the south edge of the S.W. 1 of sec. 26, T. 2, R. 6. It is here a Highest beach massive rounded ridge of gravel and sand, with descent of twelve to R. 6. fitten feet in a distance of as many rods both to the east and west from is crest, which is 1,253 feet above the sea. Northward this beach, with similar outline, extends to Francis J. Parker's house, which is milt on its crest, having there also a height of 1,253 feet, in the north wire of the N.W. 1 of this section. Westward from this beach is an adulating surface of till with few boulders. Half a mile farther north he beach is intersected by the deep and broad ravine of Dead Horse Cheval Creek. Beyond this ravine the beach begins near Samuel B. Remen's house. Its elevation one to one and a half miles north-northwest of Mr. Bowen's is 1,255 to 1,259 feet, and it is there spread more eally than usual, having a nearly flat surface on a width of twenty to Linu rods, bordered on the east by a descent of ten or fifteen feet in wenty rods, and on the west by a descent of about four feet. The each is gravel and sand, with till on each side. It has nearly the same sures also a third of a mile farther north, near the center of sec. 10, 3. R. 6, where it is crossed by the road from Morden to Thornhill, pelevation of its crest being 1,258 feet, but the depression on the est is reduced to only one or two feet. In the same section this and mer beach ridges are excavated beside the railway for ballast, and are galto consist of sand and gravel with pebbles seldom exceeding two three inches in diameter. About half of the pebbles are light gray agnesian limestone, and about half Cretaceous shale, such as forms

uches in Minnesota and North Dakota. About a quarter of a mile east of the foregoing is a parallel beach Second Herman can to twenty feet lower, the second in the Herman series. Newton 2 and 3, R. 6. mes house, next east of Mr. Oakley's, is built on its crest, 1,237 feet we the sea. It there has a descent of fifteen feet or more within an bth of a mile to the east; but on the west the descent is only one or

Pembina Mountain, with only a small proportion derived from hean rocks. Thence the highest shore continues north through the

feet or in part wanting, and a nearly level surface of sand and rel reaches west to the upper beach. In sec. 10, T. 3, R. 6, at the dfrom Morden to Thornhill, this second Herman beach has a height

Three small parallel beach ridges referable to the third stage in the Third Herman Three small parallel beach ringes relevable to the third stage in the beach, Ts. 2 and Herman series are crossed in the west part of sec. 24, T. 2, R. 6, by the road leading northwest from Mountain City. The elevation of their crests is 1,198, 1,202, and 1,205 feet. Two miles farther north, near the center of sec. 35 in the same township, William Miller's house in built on the highest of these, at an elevation of about 1,210 feet. His well, sixteen feet deep, is gravel and sand to the depth of twelve feet with till below. Northward these beaches are traceable through wex 2, 11, 15, and the south part of 22, T. 3, R. 6, to Bradshaw's Cheek beyond which they pass, with the other Herman and Norcross beaches along the Pembina Mountain escarpment.

Fourth Herman beach, Ts. 2 and 3, R. 6,

The fourth Herman beach passes through Mountain City, in sec. 21 T. 2. R. 6, the post-office and the south end of the principal street being on its crest, at 1,191 to 1,192 feet. Twenty-five rods farther each the school-house is a less conspicuous parallel beach, at 1,183 to 138 feet. Both are terrace-like in form, having a descent of three to fin feet or more on the east but only one to two feet or none on the week The continuation of this shore was also observed, like the precede through a distance of six miles northward.

Pembina Mountain from Thorn**h**ill to 1rcherne

From sec. 28, T. 3, R. 6, the Herman shores of Lake Agassiz coincil with the prominent escarpment of the Pembina Mountain through distance of twenty-nine miles, passing in a nearly straight course nor northwesterly to sec. 30, T. 7, R. 8, about seven miles east-southers from Treherne. Along this distance the base of the escarpment 1,100 to 1,125 feet above the sea, and its crest about 1,400 feet. Se from this elevation, the great plain of the Red River Valley on the ess when overshading clouds give to it in the distance a dark blue or azm color, appears not unlike the vast expanse of the ocean as viewed in an equal height a few miles inland. The highest shore of the gladi lake was about half-way up this ascent, and the lower Herman beach and those of the Norcross stage were between this and the base.

Sec. 30 T. 7. R. 9.

At the north end of the Pembina Mountain the Herman shore Lake Agassiz turned from a northward to a westward course, and the sharpest portion of this bend, in sec. 36, T. 7, R. 9, the current along the shore, caused by storms, brought a large amount of gran and sand from their erosion on each side, and accumulated the deposits in a massive ridge which juts out north-northwesterly an or more from the curving line of the escarpment. This gravels sand spit sinks from nearly 1,300 feet above the sea at its souths

where it rests on deposits of the s

Five to six mil in the gradual a Treherne. The ec. 31, T. 7, R. pebbles mostly o hove the sen. nile south to the nom them by a he second (b) in (a and aa) not be hat appermost be centry northwai ts termination be he east part of th te south from T. each just describ nd gravel deposi addivisions (b1 ar orth the third H the south edge rest at 1,243 and de. Mr. Scarrov al. 2 feet: inter ravel, 5 feet; bed ry hard dark bl ell shows an acci rept out by the e rned westward. other beach, also 236 and 1,238 feet ope. At the sum stof the Little B assive beach dep tion of northwest ountain. The su

220 feet above th

oad swell from w

st sides. Arthu

ds of sand and s

m their lower po

reen this and the lake level as on re such an inter-

hird stage in th T. 2, R. 6, by th. elevation of their rther north, near Miller's house's t 1,210 feet. His th of twelve feet

able through ses

Bradshaw's Cles

Norcross beaches

in City, in sec. 3 cipal street beat de farther east. , at 1,183 to 1.14 nt of three to the none on the west ke the precessal

e Agassiz coinci ountain through right course non iles east-souther the escarpment 1,400 feet. Valley on the ea dark blue or a an as viewed to ore of the gla r Herman bea nd the base. Herman shore

ard course, and R. 9, the curren amount of giar ccumulated tis rthwesterly and

This gravel. ea at its souther where it rests on the adjoining highland to about 1,125 feet, comprising deposits of the successive Herman, Norcross, and Tintah stages of the

Five to six miles farther west the Herman beaches are well exhibited in the gradual ascent that rises to the Tiger Hills one mile south of Treherne. The highest beach here crosses the middle of the N.W. 1 of sec. 31, T. 7, R. 9, where it forms a swell of sand and gravel, with addles mostly of Cretaceous shale, having its crest 1,272 to 1,273 feet bye the sea. In some portions this reaches nearly flat an eighth of a mile south to the base of the Tiger Hills, but elsewhere it is divided tom them by a depression of three to five feet. This appears to be the second (b) in the series of Herman beaches, the first of this series gand aa) not being found here nor farther north. At the time when hat appermost beach of Lake Agassiz was formed, this locality and the ountry northward are believed to have been covered by the ice-sheet, stermination being at the tract of morainic drift which overspreads be east part of the Tiger Hills, as crossed in T. 7, R. 9, by the road to he south from Treherne. About twenty and fifty rods north of the each just described, two inconspicuous beach lines, terrace-like sand Vicinity of at gravel deposits, are found at 1,266 and 1,254 feet, referable to addivisions (b¹ and bb) of the second Herman stage. A little further orth the third Herman beach is represented at Irvine Scarrow's house the south edge of sec. 6, T. 8, R. 9. This is a slight terrace with $_{
m red 31}$ 1,243 and 1,244 feet and descent of four or five feet on its north ic. Mr. Scarrow's well on this beach, 31 feet deep, consists of black al. 2 feet: interbedded sand and clay, 10 feet; very coarse shale muel 5 feet; beds of coarse and fine gravel and sand, 13 feet; and gy hard dark bluish till at the bottom, dug into only 1 foot. This shows an accumulation of shore drift to a depth of thirty feet, pt out by the currents of the lake from the curve where its beaches med westward. About an eighth of a mile north of Mr. Scarrow's ther beach, also referable to the third Herman stage, descends from 236 and 1,238 feet at its crest to 1,230 feet at the base of its northward pe. At the summit of the Manitoba & Southwestern Railway a mile of the Little Boyne River, and on the slope thence eastward, very wive beach deposits are accumulated, due apparently to the same con of northwestward currents from the northern end of the Pembina antain. The summit of the railway is on such a beach, 1,217 to 20 feet above the sea, the fourth in the Herman series, forming a ad swell from which a gentle slope falls on its northeast and southst sides. Arthur Willett's well here goes to a depth of 42 feet in s of sand and gravel, obtaining a plentiful supply of good water in their lower portion, without reaching their bottom. A fifth of a

mile farther east the railway cuts a beach ridge with its crest at L211 feet, also referable to the fourth Herman stage,

The Assiniboine delta occupies the western border of Lake Agasia from Treherne westward about sixty miles to Brandon and their northeastward about thirty-five miles to Neepawa. The shore of the lake along these distances is not generally marked by a definite beast ridge, the absence of which seems to be accounted for chiefly by the extreme shallowness of the lake upon the delta, so that powerful waves were not driven ashore by storms. The course of the highest shear Treherne between Treherne and Brandon, belonging to the time of the second

Highest shore trom Treue to Brandon.

Herman beach, passes first west-southwest along the foot of the Tige Hills to the north and west side of Campbell's Hill in sec. 4, T. 7, R.P. thence southwest and south to the Cypress River near Grange post-offin sec. 18, T. 6, R. 12; thence west-northwestward to Oak Creek and along the south side of this creek, within a mile or less from it, nearly to its mouth; and, crossing the Souris in sec. 31, T. 7, R. 16, Dass thence northwest to Brandon. Beyond the Cypress a belt of F moderately undulating or in part nearly flat, from two or three to . miles wide, separates this lake shore from the northern border of i Tiger Hills and the eastern and northern base of the Brandon Hill. S. Martin's house, in the N.E. 1 of sec. 28, T. S. R. 17, about fifteen miles southeast of Brandon, is built on a small beach ridge of sand and gravel extending from southeast to northwest, only slightly below i highest stage of the lake, which is marked by a moderately slopiparallel escarpment, about ten feet high, croded in till a half m southwest of this beach. The unusually smoothed surface of the extending thence west and south to the Brandon and Tiger Hills. the area crossed by the Souris in its course from Gregory's mill to the mouth of Black Creek, is probably attributable to the deposition of upper portion in a body of water held between these hills and to northwardly retreating ice-sheet before this area was drained to level of Lake Agassiz by the retreat of the ice from the east part the Tiger Hills and the north end of the Pembina Mountain.

In the south part of the city of Brandon the second Herman bead marking the stage bb of the table in a subsequent part of this report a well defined ridge of sand and gravel along a distance of about a n.s. It extends from east to west, passing an eighth of a mile north of court house, and thence close along the south side of Lorne Ave.a from First to Fourth Streets. Between Fourth and Sixth Streets it erossed by this avenue, and thence westward lies close on its north sile Its structure is shown by sections where it is intersected by Tent Eleventh and Twelfth Streets, exposing a thickness of ten feet obliquely bedded sand and gravel containing abundant pebbles up

Second Herman beach, Brandon.

two inches and mothirds being one-fourth Cret granites and sel in width and fro rounded wave-lil ranges from 1,2 Twelfth Streets slightly higher vicinity of Bran afforded in the se ravel and sand 1282 feet above one miles west e more fally notice North of the A from Brandon eas miose below the and and, which li mile north of D early at the mid Thence its course scarpment, exter et and less dist his escarpment w 1,269 feet above a mile farther astward is delta s sing thence slow he between a m leatiful boulders e land gravel de iea, passes north-12 and the east er of sections in ! proximately, the stinct beach ridg allow on the adjo ends of the inequ

est, transverse to

taches would be fo

avel and sand in

cumulated in a di

s crest at 1.21;

of Lake Agass, ion and there The shore of the a definite bear r chiefly by th powerful waves e highest shop e of the second oot of the Tiger ec. 4, T. 7, R.12 range post-di : Oak Creek and s from it, nearly . 7. R. 16, pass

s a belt of f. o or three to s ern borders: e Brandon Hi. 17, about fifteen ridge of sandad lightly below the derately sloping till a half mile surface of the d Tiger Hills.

cory's mill to the deposition of ese hills and t s drained to the east part ountain. l Herman beat

t of this report e of about a n. s nile north of t of Lorne Ave. ixth Streets ! on its north sile sected by Tenta ss of ten feet nt pebbles up

reguinches and rarely cobbles three or four inches in diameter, about prothirds being Paleozoic magnesian limestones, from one-tenth to and the remainder mostly Archaen granites and schists. This beach ridge varies from ten to twenty rods in width and from five to ten feet or more in height, having a smoothly munded wave-like form. The elevation of its crest near the court house ranges from 1,260 to 1,269 feet above the sea, and at Eleventh and Twelfth Streets it is 1,260 to 1,261 feet. No distinct beach ridge of the slightly higher Herman b stage of Lake Agassiz was found in the vicinity of Brandon, but evidence of the lake level in that stage is afforded in the southeast part of Brandon by the delta plateau of coarse eravel and sand at the court house and eastward, which is 1,270 to 1282 feet above the sea, and by an old water-course crossed three to fremiles west of Brandon on the road to Kemnay, both of which are , we fully noticed in the description of the Assiniboine delta.

North of the Assiniboine the highest shore of Lake Agassiz passes from Brandon east and east-northeast by Chater and Douglas, being on Highest shore cclose below the verge of the plateau of till, overspread by delta gravel from Brand to Neepawa. and sand, which lies close north of the Canadian Pacific Railway. About mile north of Douglas station this shore is marked by a dune hillock, early at the middle of the line between sections 10 and 11, T. 11, R. 17. Learchits course is north-northeastward, and is indicated by an eroded scarpment, extending two or three miles with a height of ten to fifteen et and less distinctly observable a few miles beyond. The base of his escarpment where it crosses the south line of sec. 24 in this township 1269 feet above the sea; and the surface at the school-house a sixth fa mile farther west is about twenty feet higher. All the area stward is delta sand and gravel; but the escarpment and the country sing thence slowly northwestward are till. The continuation of this me between a moderately rolling surface of till on the west, with eniful boulders and frequent lakelets, and the slightly undulating and and gravel delta on the east, with low dunes on many parts of its nga passes north-northeasterly in range sixteen across the west half of 12 and the east half of T. 13, and thence north through the eastmost er of sections in T. 14, to Stony Creek. It evidently marks, at least peroximately, the highest shore of the glacial lake; but it bears no stinct beach ridge nor line of erosion, partry because the lake was so allow on the adjoining delta area, and partly because the prevailing ends of the inequalities in the till surface run nearly from east to et, transverse to the course of the shore currents and drift by which eaches would be formed, thus intercepting the scanty deposits of beach avel and sand in their hollows, instead of permitting them to be cumulated in a distinct ridge.

The Manitoba & Northwestern Railway crosses two beach ridges at Near Neepawa, three and three-fourths miles and three miles west of Neepawa, the crests of which are respectively 1,323 and 1,304 feet above the sea. These elevations indicate that they belong to subdivisions of the second Herman stage, in the same manner that this stage is represented by three beach lines at Treherne. Each of these ridges has a height of about seven feet above the adjoining surface, and a width of thirty to forty rods. They consist of sand and gravel, and the railway company has therefore purchased a considerable tract occupied by the lower one of them for its excavation and use as railway ballast. This lower beach probably marks the same lake level as the beach observed at Brandon, having there an elevation of 1,260 to 1,269 feet. Gravel and sand brought into Lake Agassiz by Stony Creek seem to have contributed to the conspicuous development of beach deposits here, while they are wanting or less distinct upon most of the shore southward to Brandon and also northward through the next twelve miles to where the Herman and Norcross shores pass into the steep escarpment that forms the eastern face of Riding Mountain.

BEACHES OF THE NORCROSS STAGES.

Tarough T. 1, R. 5, the Norcross shores of Lake Agassiz lie on the East of Moun-escarpment of the Pembina Mountain; and the first observations at the first peaches were in secs. 7, 18 and 19, T. 2, R. 5, where the mountain wall is reduced to a gradual ascent in the vicinity of Mountain City and Thornhill. About a half mile southeast of Mountain City the upper Norcross beach is well displayed at John Borthwick's house, which is built on its crest, 1,167 feet above the sea, in the southwest corner of sec. 19. Digging for wells here shows that the gravel and sand of the beach extend only to a depth of six or eight feet, there resting on the Fort Pierre shale. From the crest of this beach ridge its slopes in eight or ten feet within a few rods on the east and about four feet on the west. It is bordered on the west at this locality by a surface strewn with very abundant boulders up to five feet or rarely more diameter, nearly all being Archean granites, with perhaps a third of one per cent. magnesian limestone. Generally, however, the surface in this vicinity has few or no boulders; and a shallow depth of ordinary till or of lacustrine deposits overlies the Cretaceous shale. The second Norcross beach, also forming a distinct ridge, lies a third of a mass farther east, with its crest about 1,150 feet above the sea. A large exeavation for sand to be used in plastering has been made in this ridg, in the south edge of this sec, 19, A mile farther south John W Stodders' house is built on it at an elevation of 1,148 feet. His well

twelve feet dee enters the shall a hard calcar Pieces of the 1 plainly marked is traceable thr western Branch miles east of T Treherne they About one a Treherne the Ma beach ridge, the dabout five fee farther east it cu from which ther me east. This i mack being run

from the railway

six to eight rods nat the ridge is

isand constitut

shale a foot acro estimate, nearly 1 which makes up Tiger Hills, and 1 unmixed with ot lasses of limeste clowish gray, siliterous, which Assiniboine Rivers bout Lakes Mani om the Archaenn Continuing north rosses secs. 8 and evend which it i lown surface of th The next definit

ear Neepawa, wi

he west of this

oper Norcross sta

Close to the

5

each ridges at Neepawa, the above the sea. s of the second represented by as a height or th of thirty to lway company the lower one his lower beach ed at Brandon. ravel and sand e contributed to while they are ard to Brandon ere the Herman

that forms the

gassiz lie on the observations of re the mounta. ountain City and City the upper house, which thwest corner and sand of the re resting on the ge its slopes ta out four feet ty by a surface rarely more a rhaps a third er, the surface is epth of ordinar ale. The second third of a mil ie sea. A lanz ade in this ridge south John W.

feet. His we

twelve feet deep, passes through gravel and sand, eleven feet; and then enters the shale, the top of which, to a depth of six to twelve inches, is a hard calcareous layer, including nodules and veins of calc spar. Pieces of the hard surface of this layer, thrown out of the well, were painly marked with glacial strike. The continuation of these beaches is traceable through the next seven miles northward across the South-restern Branch of the Canadian Pacific Railway, passing about three niles east of Thornhill, to Bradshaw's Creek, beyond which to near Treherne they again coincide with the Pembina Mountain escarpment.

About one and a half miles east of the Little Boyne River near Treherne the Manitoba & Southwestern Railway cuts the upper Norcross Near Treherne. beach ridge, the crest of which is 1,195 feet above the sea, with a descent fabout five feet on the west and ten feet on the east. A half mile auther east it cuts the lower Norcross beach, with its crest at 1,167 feet, com which there is a descent of ten feet to the west and fifteen feet to i.e cast. This beach has been extensively excavated for ballast, a spur tack being run along its course a quarter of a mile northwestward com the railway. The excavation, varying along this distance from six to eight rods in width and from five to fifteen feet in depth, shows the ridge is composed of interbedded sand and gravel, the layers sand constituting about half of the entire deposit. The gravel layers differ in coarseness from those that contain no pebbles more than one or two inches in diameter to others containing water-worn masses of shale a foot across and Archean cobbles six inches in diameter. By cimate, nearly nine tenths of the gravel is the hard Fort Pierre shale which makes up the principal mass of the Pembina Mountain, the Let Hills, and Riding Mountain, this shale gravel being often almost mmixed with other material; about a twentieth part consists of two classes of limestones, derived in nearly equal proportions from the chowish gray, arenaceous limestone of Niobrara age, plentifully siliferous, which outcrops beneath this shale on the Boyne and miniboine Rivers, and from the Palæozoic limestones of the flat country jout Lakes Manitoba and Winnipeg; and the remaining twentieth is on the Archæan rocks that lie east and north of Lake Winnipegminuing northwesterly and northerly, this massive beach ridge esses sees, 8 and 17, and the eastern edge of sec. 19, T. 8, R. 9, and which it is lost sight of on the undulating and partly windown surface of the Assiniboine delta.

The next definite observations of the Norcross shores of this lake are ar Neepawa, where the Manitoba & Northwestern Railway a half newest of this station crosses small beach ridges referable to the per Norcross stage, with their crests 1,223 to 1,225 feet above the a. Close to the west is an eroded escarpment of till fifteen feet high,

rising from 1,225 to 1,240 feet. On the other side of the station between a half mile and one mile east from it, the railway crosses a surface of wind-blown sand with hollows two to four feet deep, the crests of its low dunes being at 1,193 to 1,192 feet. These occupy the level belonging to the lower Norcross beach. The bed of the railway here, formed of the sand of the Assiniboine delta, further worn and redeposited by the lake waves, proves somewhat insecure because of its iability to be channelled by the wind. The road leading northward from Neepawa to Eden and Riding Mountain runs on the crest of the oper Norcross beach ridge through the east part of secs. 21 and 28. 15, R. 15, three to five miles north of the railway, its crest there having a nearly constant height of 1,223 feet, with a descent of five or six feet from it to the east and half as much to the west. Thence this beach ridge continues north-northeasterly to the east part of sec. 23 T. 16, R. 15, where it has an elevation of 1,225 to 1,230 feet, with width of about thirty rods and descent of ten to fifteen feet on its east side It next runs north or slightly west of north to Thunder Creek in the south part of T. 17, beyond which its course, with that of the lower Norcross shore, is along the steep ascent of Riding Mountain. In the journey from Eden post-office (S.W. + of sec. 22, T. 16, R. 15) to Orange Ridge post-office (N.W. 1 of sec. 32, T. 16, R. 14), a nearly flat surface of all with frequent boulders is crossed upon the width of three miles Letween this beach and the upper Campbell beach, descending in that distance from 1,200 to 1,100 feet, approximately. Boulders at especially abundant within the first mile from the upper Norcess

BEACHES OF THE TINTAH STAGES.

beach, whence the erosion of the lake bed supplied its gravel and said

This even tract of till would seem most favorable for the accumulation

of the beaches belonging to stages of Lake Agassiz between its upper

Norcross and upper Campbell levels; but no beach ridge nor other

deposit of gravel and sand, nor line of erosion which sometimes take

the place of these to mark a shore line, was seen in the intervenia;

distance. It seems probable that not far south and north from this

route of observation the lower Norcross and the two Tintah beader

Ts, 1 and 2.

will be found.

In proceeding northward from the international boundary the Tintal beaches were first observed near the line between Ts. 1 and 2. R. I lying on a terrace which forms the lower part of the Pemblia Mountain. On the boundary this terrace is about three fourths of a mile wide, its eastern margin being an escarpment that rises from 1.94 to 1,090 or 1,095 feet; and from its verge it gradually rises 25 to 3 feet in its width, so that its western limit at the base of the man

escarpment ha pentiful bould mostly embedd east side consis is thus shown t untle of till. terrace widens but it is border the base of wl boundary. In hase of the mou athird of a mi 1.110 to 1,125 f In the S.E. | of gravel and sand Tintah beach lie of gravel and sa side by till, the feet lower on th the N.E. + of s : derlain by th ferm, like the f ension of these countain, with a South Branch of twenty-five miles whole extent it . west, as in the lo boulders, but so over-pread with ensisting of Cre lacustrine deposi

scent of about for the sen. Within beach, a small ric use in plastering, five or six feet fre extends a conside terrace. The roa males across a son rilges are discorr llerman stages.

A mile west of

f the station. way crosses a feet deep, the ese occupy the of the railway her worn and e because of its ing northward he crest of the ees. 21 and 28. its crest there scent of five or t. Thence this part of sec. 2; feet, with width on its east side er Creek in the at of the lower untain. In the R. 15) to Orange early flat surface h of three miles

scending in that Boulders at upper Norcross gravel and sand he accumulation etween its upper ridge nor other sometimes take the intervening north from this Tintah beaches

dary the Tintal s. 1 and 2, R.5 of the Pembin aree fourths of i rises from 1.04 ly rises 25 to 3 mse of the man

scarpment has a height of 1,120 to 1,125 feet. Its surface is till with pentiful boulders, nearly all Archean, up to five feet in diameter. mostly embedded or only projecting a foot or less; but the slope on its gest side consists of weathering and pulverized Cretaceous shale, which is thus shown to form the principal mass of the terrace, beneath a thin nantle of till. In the distance of six miles northward across T. 1, this terrace widens to two miles, and its eastern verge sinks to 1,055 feet; but it is bordered by only a slight escarpment, about fifteen feet high. the base of which is thus at the same level as on the international soundary. In its width of two miles it there rises about 90 feet, to the lose of the mountain escarpment at 1,140 to 1,150 feet. A quarter to a hird of a mile east of this escarpment a line of erosion rises from 1110 to 1,125 feet, approximately, marking the upper Tintah shore In the S.E. 1 of sec. 5, T. 2, this shore bears scanty deposits of beach ravel and sand, with their crest at 1,110 to 1,115 feet. The leave Tintah beach lies a third of a mile farther east, and is a distinct : Fre eferavel and sand with its crest at 1,083 to 1,085 feet, bordered on each sile by till, the surface of which is five feet lower on the east and three feet lower on the west. Thomas Kennedy's well, fourteen feet dear in as N.E. 1 of sec. 5, T. 2, R. 5, found the till only four feet deep, aderlain by the Fort Pierre shale. This terrace doubtless owes its firm, like the far more prominent Pembina Mountain, to preglacial erosion of these Cretaceous beds. It continues along the foot of the countain, with a width of one and a half to two miles, at least to the South Branch of Tobacco Creek, which crosses it near Miami post-office, twenty-five miles north of the international boundary. Throughout its whole extent it has a considerable ascent upon its width from east to sest as in the localities noted. Much of its surface is till with many bulders, but some portions have no boulders, such tracts being overspread with lacustrine gravel and sand, or perhaps occasionally consisting of Cretaceous shale next below the soil, with no drift nor lacustrine deposits.

A mile west of Morden the escarpment bordering this terrace has an scent of about forty feet, with its top approximately 1,070 feet above Morden. the sea. Within an eighth of a mile to the west is the lower Tintah heach, a small ridge of gravel and sand which has been excavated for use in plastering, its crest being at 1,085 feet, nearly, with a descent of five or six feet from it to the east and two or three feet to the west. It extends a considerable distance nearly parallel with the verge of the terrace. The road thence to Thornhill ascends slowly in the next two miles across a somewhat uneven surface, on which eight or ten beach rilges are discernible, belonging to the upper Tintah, Norcross, and

Herman stages.

Abundant

The most remarkable feature of this tract is its extraordinary abundance of boulders, nearly all Archæan, usually less than five feet in diameter, but in many places ranging in size to ten feet or more. Upon an area that extends at least one to two miles both south and north of the road and railway, the surface is as thickly strewn with boulders as are the most typical terminal moraines seen by me in Minnesota and South and North Dakota. Many of these rock-masses instead of being imbedded in the drift, as is generally the case in this region, project two to three or four feet above the surface, or lie wholly on it with no portion concealed. Here the ice-sheet probably terminated, depositing these boulders in the west margin of Lake Agassiz during the time of its accumulation of the terminal moraine that forms the west part of the Tiger Hills and the Brandon and Arrow Hills

Near Nelson.

About a mile south and west of Nelson, the lower Tintah beach ridge, having an elevation of 1,085 feet, approximately, lies an eighth of a mile west from the margin of the terrace; and the upper Tintah beach probably extends along its west side, close to the base of the Pembina Mountain, where the elevation is about 1,100 to 1,120 feet. The width of the terrace here is about one and a quarter miles.

East of Treherne A half mile east of the lower Norcross beach near Treherne, the apper Tintah shore seems to be indicated where it crosses the railway by a line of erosion in the Assiniboine delta, with descent approximately from 1.140 to 1.120 feet.

Northeast of Neepawa. On the profile of the Manitoba & Northwestern Railway the upper and lower Tintah beaches are apparently shown about three miles and five and a half miles east-northeast of Neepawa, with their crests respectively at 1.158 feet and in two ridges at 1.116 and 1.111 feet above the sea. Within its next three miles northward the upper beach is represented by a tract of low dunes extending through the east edge of T. 15, R. 15, to Snake Creek. Thence the course of these shore lines as shown by the contour, is nearly due north to the foot of the escarpment of Riding Mountain in T. 17.

BEACHES OF THE CAMPBELL STAGES.

Along the course of the Cretaceous terrace which borders the base: the Pembina Mountain for at least twenty-five miles northward from the international boundary, as described in connection with the Tintah beaches, the upper Campbell shore line, there having an elevation of 1,045 to 1,050 feet, coincides with the low escarpment which forms the east margin of this terrace. A portion of the sculpturing of this escarpment was doubtless done by the waves of the lake; but the main outlines of the terrace as a bench intermediate between the expansed

MANC the Red River attributable to a distinct beac sec. 3, T. 4, R distance of a n the terrace esc 1.055 feet. In ridge, passing eighth to a half 1.055 to 1.060 f ifteen feet on t this stage, or at is twenty feet pases northwe corthward thro

> upper Campbell its crest is 1,03 extends an eight gravel and sand similarly descen twenty-five rods eastward. The shore about thre 34, T. 1, where i 1.034 feet, from east and three or to hold nearly th mile or more to About a half m excavated for pl rods wide, with a mately, resting miles farther nor of this beach thro T. 4. R. 6. It is to thirty rods wie ten feet above No sec. 6, T. 5, R. 6,

railway about so

The lower Ca

national bounds

The course of t

Upper Campbell shore from the international boundary to extraordinary than five feet feet or more, oth south and y strewn with een by me in e rock-masses. he case in this or lie wholly robably termi. Lake Agassiz. moraine that d Arrow Hills. ah beach ridge, an eighth of a r Tintah beach of the Pembina

Treherne, the ses the railway approximately

eet. The width

lwny the upper three miles and ith their crests and 1,111 feet the upper beach the east edge hese shore lines. t of the escarp-

rders the based northward from with the Tintah an elevation of which forms the pturing of this e; but the main n the expanse of the Red River Valley and the high Pembina escarpment seem clearly attributable to preglacial erosion. The first locality where I observed adistinct beach ridge of gravel and sand referable to this stage is in sec. 3, T. 4, R. 6, a half mile west of Nelson, and thence through a listance of a mile or more north-northwestward. It lies close east of the terrace escarpment, and has an estimated elevation at its crest of 1,055 feet. In T. 7, R. 8, this shore is marked by a conspicuous beach ridge, passing through sees, 22, 27, and the east edge of 33, lying an eighth to a half of a mile west of the Boyne River, with its crest about 1,055 to 1,060 feet above the sea. The descent from the crest is ten to ffeen feet on the east, and five to eight feet on the west. The lake at this stage, or at a slightly higher level, also cut an escarpment fifteen twenty feet high, with its top at 1,075 feet, approximately, which BISSES BOTHWESTWARD ACROSS Secs. 28 and 29 of this township and northward through the east part of secs, 6 and 7, T. 8, crossing the railway about seven miles east of Treherne.

The lower Campbell beach in its course northward from the inter-national boundary lies close east of the terrace face which was the Campbell shore apper Campbell shore. In secs. 2 and 11, T. 1, R. 5, the elevation of distance. its crest is 1,036 to 1,040 feet. On the west a nearly level surface extends an eighth of a mile to the terrace. On the east a slope of beach gravel and sand sinks to 1,028 feet in about twenty-five rods; and a similarly descending surface of till continues to 1,015 feet in the next twenty-five rods, beyond which there is a much slower descent rastward. The road on the line between Ts, 1 and 2, R. 5, crosses this shore about three eighths of a mile west of the northeast corner of sec. 34 T. 1, where it is marked by a typical beach ridge, with its crest at 1,034 feet, from which there is a descent of ten feet in ten rods to the estand three or four feet in ten rods to the west. This ridge was seen to hold nearly the same outline and height through a distance of one mile or more to the south and a half mile north to a small creek. About a half mile west of Morden, where it has been considerably excavated for plastering sand, it has a nearly flat top ten to twenty pds wide, with ascent on this width from 1,030 to 1,040 feet, approximately, resting on the base of the terrace escarpment. Five to six miles farther north, the road from Nelson to Miami runs along the top of this beach through the north half of sec. 3 and the S.W. + of sec. 10, T.4. R. 6. It is there a broad, low ridge of sand and gravel, twenty to thirty rods wide, the elevation of its crest being about 1,035 feet, or ten feet above Nelson. Continuing northward, it crosses the N.E. 1 of sec. 6, T. 5, R. 6, a mile west of Miami.

The course of these shore lines was not traced across the Assiniboine delta, but their elevation shows that they lie on its eastward slope

where they are intersected by numerous ravines and are doubtless obscured in many places among its dunes. On the Canadian Pacing Railway profile three massive beach ridges, the two higher referable to the upper Campbell stage, and the third to the lower Campbell stage of the lake, are shown three miles to two and a half miles wested Austin, their crosss being respectively 1,087, 1,081, and 1,066 feet above

West of Austin. Austin, their crosts being respectively 1,087, 1,081, and 1,066 feet above the sea. These beaches are each about thirty rods wide, with descent of ten to twenty feet from their crosts to their east bases and half as

much to the west.

On the Manitoba & Northwestern Railway the upper Campbell beach

Vicinity of

Beautiful Plai

is a very massive rounded ridge, thirty to fifty rods wide, along whose eastern slope the railway runs about three miles, from the south side of sec. 6, T. 15, R. 13, north-northwest to Arden. Before the railway was built, the old trail from Winnipeg to the Saskatchewan River passed along the top of this ridge the same distance and to a point about a mile north of Arden, there leaving it and turning to the west. This portion of the trail was a good dry road throughout the year, being thus remarkably contrasted with the deep mud along most of its extent during rainy seasons. Because of this character of the road and the beauty of the smooth beach, which is prairie, without tree or bush, but is bordered on each side by groves, this avenue-like tract received is widely known name, the Beautiful Plain. It is not flat, however, as the name seems to imply; for the crest of the beach ridge, at Arden 1.00 feet above the sea, and not varying more than a few feet above .. below this elevation in its course through several miles south and north, is fifteen to twenty-five feet above the nearly straight marginthe woods an eighth to a quarter of a mile east, and seven to ten feet above the more irregular margin of bushes and woods on the west commonly ten to thirty rods distant. The barrier of this beach ridge was sufficient to turn the White Mud River southward three miles along its west side. In a section cut six feet deep close north of Ardel for the passage of the railway and in excavation of ballast, the material of this beach is mainly fine gravel with publics only a quarter to a third of an inch in diameter, but also includes layers of sand and coarse gravel, with pebbles up to two inches in diameter, of which about three quarters are from the Palaeozoic formations of magnesial

From Arden this beach extends north-northwest through the northeast part of T. 15 and nearly through the center of T. 16, R. 14. In the north half of T. 16 it has in several places a narrow terrace-like secondary beach on its eastern slope five to ten feet below the crest of the main beach; and it is closely bordered on the west by a lox escarpment of till which rises five to ten feet above the beach ridge and

limestone that occupy the country eastward to Lake Winnipeg.

×4V

forms the man ascends slowly beach and oscaallusion to the grow in abundaelevation of the line of the N.E. the sea; and of the early part of

southeast corne is 1,061 feet, v the cast and fiv fifteen miles not leautiful Plain between Ts. 16 feet, with descer

The lower (

The northwar sees, 5 and 8, T. west of north t Thence they tra east part of T. 18 wide separates t

1

In the S.W. \(\) indicated by ver above the sea, for twenty rods east, and the west half are developed as one has an elevat is a descent of one five to eight feet i level surface of \(\) twelve rods, and western slope of about tive feet low five feet or more of

About a quarte shore is a line of a distance from wes

are doubtless nadian Pacific gher referable Jamphell stage ' miles west of ,066 feet above with descents ses and half as

Campbell beach e, along whom he south side of he railway was n River passed int about a mile . This portion ar, being thus t of its extent ie road and the ree or bush, but act received is. however, as tie at Arden Lu-

v feet above niles south and aight marging even to ten feet ds on the west this beach ridge ard three miles north of Arder of ballast, the sonly a quarter ers of sand and neter, of which is of magnesian innipeg. through 1

of T. 16, R. 14 ow terrace-like ow the crest of west by a low

beach ridge and

forms the margin of a flat or slightly uneven expanse of till that ascends slowly westward. A post-office situated close west of this heach and escarpment in sec. 32, T. 16, is named Orange Ridge, in Orange Ridge. allusion to the orange-red lilies (Lilium Philadelphicum, L.) which gow in abundance on the sandy and gravelly soil of the beach. The devation of the Orange Ridge or Beautiful Plain beach on the north fine of the N.E. ‡ of sec. 32, T. 16, is approximately 1,080 feet above the sea; and of the escarpment on the west, which was eroded during the early part of this upper Campbell stage, 1,090 feet.

The lower Campbell beach is crossed by the railway near the Lower Campbell beach near outheast corner of sec. 6, T. 15, R. 13, where the elevation of its crest hell beach near and about fifteen rolls to transport for the country of the countr is 1,061 feet, with a descent of eight feet in about fifteen rods to the east and five feet in a few rods to the west. Through the next fifteen miles northward it lies a half to two thirds of a mile east of the Reantiful Plain and Orange Ridge. East of the latter, on the line between Ts. 16 and 17, R. 14, the elevation of its crest is about 1,070 het with descent of fifteen feet to the east and ten feet to the west,

The northward continuations of the Campbell beaches pass through $_{T8,\ 17\ and\ 18,\ secs.}$ 5 and 8, T. 17, R. 14, to Thunder Creek, and thence a few degrees $^{Rs.\ 14}$ and 15 . west of north to the Big Grass River in sec, 31 of this township, Thence they traverse sees. 6, 7 and 18 in T. 18, R. 14, and the northest part of T. 18, R. 15, where a swamp on the west about two mile wide separates them from the base of the Riding Mountain.

BEACHES OF THE M'CAULEYVILLE STAGES.

In the S.W. 1 of sec. 12, T. 1, R. 5, the upper McCauleyville shore is T. 1, R. 5. indicated by very scanty deposits of fine gravel, 1,006 to 1,007 feet above the sea, from which there is a descent of three or four feet in wenty rods east. Through the east half of sec. 23, the middle of 26, and the west half of sec. 35 of this anship, two McCauleyville beaches are developed as small parallel ridges of gravel and sand. The upper one has an elevation of 1,000 to 1,002 feet at its crest, from which there is a descent of one to two feet within two or three rods to the west and five to eight feet in ten or twelve rods to the east. Thence a nearly level surface of fill with frequent boulders occupies a width of ten or twelve rods, and is succeeded on the east by the second ridge, the western slope of which rises two or three feet to its crest. This is about five feet lower than the upper beach, and has a similar descent of five feet or more on its east side.

About a quarter of a mile east of Nelson the upper McCauleyville From Nelson to there is a line of erosion with a descent of five to ten feet within a short Miami distance from west to east. Four miles thence to the north-northwest

it is a well defined beach ridge running close to the bridge over Boyl's Creek, near the northeast corner of sec. 21, T. 4, R. 6; and it continues, but is less conspicuous, through the next three miles northward to the church in the northeast corner of sec. 5, T. 5, R. 6, a quarter of a mile east of Miami post-office. Its crest at Boyd's Creek is eight to ten feet, and at Miami five feet, above the more massive second or middle McCauleyville beach, which lies a quarter to a half of a mile farthee east, passing north-northwesterly through the west edge of sec. 27 and the east half of sec. 33, T. 4, in which latter it is offset nearly a quarter of a mile to the east, and through the middle of sec. 4 and the west half of sec. 9, T. 5.

Three McCauleyville beach ridges are crossed by the Manitola & Northwestern Railway on the north side of secs. 32 and 33. T. 14, R. 13.

East and north about four miles, four and a half, and five miles southeast of Arden. the elevations of their crests being respectively 1.039, 1.029, and 1 as

about four miles, four and a half, and five miles southeast of Arden, the elevations of their crests being respectively 1.039, 1.029, and 1.016 feet above the sea. Each of these rises about five feet above the surface on the east. They continue as prominent gravel ridges north-north-westward through the west half of T. 15, and the southwest part of T. 16, R. 13, and through the northeast part of T. 16, the east half of T. 17, and the west half of T. 18, R. 14, to the vicinity of Phillipranch. In T. 15, R. 13, next east of Arden, the most western and upper one of these beaches is called Lowdon's Ridge from Thomas Lowdon, whose house, the first built on it, is in the middle of the east edge of sec. 30. The middle beach appears to be twofold in secs. 30 and 29, Joshua Ritchie's house being built on one of its ridges and the Rose Ridge school-house a quarter of a mile farther east on the other.

Rose Ridge.

About three quarters of a mile east of the Rose Ridge is the lower McCauleyville beach, on which the trail to Lake Dauphin rms northward through Ts. 15 and 16. Lewis McGhie's house is built of the eastern slope of this beach in the N.E. 4 of sec. 28, T. 15. Lowdens Ritchie's and McGhie's wells, and others in this township on these beach ridges, pass through gravel and sand five to fifteen feet and through it below to total depths of thirty to fifty feet, obtaining water in gravely seams, from which it usually rises ten to twenty feet within a few hours, to its permanent level.

BEACHES OF LOWER STAGES WHEN LAKE AGASSIZ OUTFLOWED NORTHEASTWARD,

Blanchard beaches, T. 1, R. 4.

On the international boundary the Blanchard shore lines onter Manitoba in the west part of T. 1, R. 4, passing near Kronsfeld in sect of this township, and extending north-northwest within about a miseast of Morden, but they are not marked along this distance by distinct

beach deposits 1 crosses the Cana it forms a slight delta. On the 1 heaches appear and three fourth opper two are n quarter of a mil bordered on the by a gentle slop is a beach ridg lescent of five fo 969 feet. After Arden to Gladst very flat, except their continuation noted on the pla

The Hillsboro

sile of R. 4, and tie internationa about a half mil descent of three above the sea. Northward it pr half miles east o Henry York's he feet. Thence its east and five fee than along most and fine gravel, Twelve miles far the S.E. | of se Almasippi postascends a few fea tract of sand w showing that it derived from th delta, within a f Gladstone this b the township pla and 17, and thro The Emerado

dge over Boyds and it continue. orthward to the marter of a mile eight to ten feet cond or middle f a mile farthe: re of sec. 27 and nearly a quarter ind the westhick

the Manitoba & 33, T. 14, R. 15 heast of Arde. 1,029, and 1,016 bove the surface ges north-hori. outhwest part of the east half ... nity of Phillip. st western and e from Thomas iddle of the eas: ofold in sees, 26 s ridges and n. ist on the other ge is the lower Dauphin rus. iouse is builtie. . 15. Lowdon. p on these beat and through i. ater in gravely

OUTFLOWED

et within a few

ore lines one ronsfeld in sec ; in about a mis ance by distinct

bach deposits nor lines of erosion. The lowest of these shore lines ornses the Canadian Pacific Railway a mile west of McGregor, where McGregor. itforms a slight swell on the gentle eastward slope of the Assiniboine delta. On the Manitoba & Northwestern Railway the three Blanchard heaches appear to be identifiable, being crossed successively two miles and three fourths of a mile west and one mile east of Midway. The apper two are nearly flat tracts of fine gravel and sand, an eighth to a marter of a mile wide, at 994 and 979 feet above the sea, each being ordered on the west by a depression of about two feet and on the east a gentle slope descending four or five feet. The third and lowest a beach ridge of the usual form, about thirty rods wide, with a becent of five feet both to the east and west from its crest, which is at Me feet. After crossing the McCauleyville beaches on the way from Anden to Gladstone, the surface is wholly silt and sand, with fine gravel, Between Arden and Gladstone. very flat, excepting these slight ridges and others at lower levels. In meir continuation northward, portions of the Blanchard beaches are on the plats of the Dominion Land Surveys through Ts. 15 to 20,

The Hillsboro beach enters Manitoba near the middle of the south Hillsboro tle of R. 4, and passes north-northwestward. It is not conspicuous on beach the international boundary, but near the west line of sec. 21, T. 1, R. 4, went a half mile east of Blumenfeld, it is a noticeable ridge with a East of descent of three to five feet on the east, its crest being about 940 feet Bunnenfeld. bore the sea. Its sand has there been excavated for use in plastering. Northward it passes about a half mile east of Oesterwick, one and a laif miles east of Morden, and nearly four miles east of Miami, where Henry York's house is built on its crest at an elevation of about 950 East of Miami. leet. Thence its slopes descend fifteen feet in a short distance to the east and five feet or more to the west, the beach being much larger than along most of its course. Mr. York's cellar and well are in sand and fine gravel, but the lower land adjoining on each side is till, Twelve miles farther north this beach passes near Mr. Field's house in the S.E. of sec. 4, T. 7, R. 6, about three fourths of a mile west of Almasippi post-office. The road from Carman to Treherne there Almasippi, ascends a few feet, and in its next third of a mile northwestward crosses a tract of sand with hollows three to five feet below its highest portions slowing that it was formerly wind-blown. This beach deposit is derived from the erosion of the eastern margin of the Assiniboine delta, within a few miles to the north. On the road from Arden to Gadstone this beach was not noticed, but it seems to be traceable on the township plats northward nearly through the middle of Ts. 15, 16, and 17, and through the west part of Ts. 18, 19, and 20, in R. 12.

The Emerado beach lies two to three miles east of the last. In Ts. 1

Emerado beach.

Rheinland.

and 2, R. 4, the Mennonite villages of Rheinland, Neuenburg and Rosenthal are partly built on it. At the wind-mill in Rheinland, and thence along its course as seen for a half mile or more to the south-southeast and north-northwest, this shore is marked by an ascent of three to six feet in as many rods from east to west; and from its cress.

three to six feet in as many rods from east to west; and from its crest about 905 feet above the sea, the surface extends nearly level westward. The beach consists of loamy sand, while the adjoining land is fine lacustrine silt or clay. On the Canadian Pacific Railway this beach is raised a few feet above the general slope of the Assiniboine delta, passing in a west-northwest course two miles east and one mile north of Barga.

Bagot.

On the M. & N. W. Railway

The Manitoba & Northwestern Railway crosses it five miles west of Gladstone, where it is a ridge about thirty rods wide, wind-blown in hollows one to two feet below the crest, which is 927 to 929 feet above the sea, with descent of five feet from it to the west and twelve to fifteen feet to the east. A lower and less conspicuous beach ridge, also belonging to this stage, lies three fourths of a mile farther east, within crest at 916 feet. The Emerado beach continues north through the east part of Ts. 15 to 19, R. 12, and through the center of T. 20, to the east side of Lake Mary.

Oiata beach.

Along the course of the Ojata shore, lying between the Emerado and Gladstene beaches, no ridge of gravel and sand nor line of erosion was observed where it was crossed on the international boundary and elsewhere in this exploration in Manitoba, excepting a slight beach ridge, three to five feet high, which runs from Pomeroy in sec. 19, T.5, R. 4, north-northwest through the east part of T. 6, R. 5, passing along two miles west of Carman.

t ladstone beach. two miles west of Carman.

The Gladstone beach on the international boundary and for sevend miles thence to the north-northwest is a prominent ridge, having—ascent of ten to tifteen feet in a distance of thirty to fifty rods west from its base to its crest, which is approximately 860 feet above the sea. The slightly undulating surface of this shore deposit occupies a width of a quarter of a mile or more; and thence westward there is no note worthy descent, but a nearly level expanse. In many shallow pits day to obtain sand for masons' use, the material of the beach is shown to be fine sand, unmixed with gravel, excepting that very rarely a pebble is found enclosed in it, the largest being a half to two thirds of an inchirdiameter. This ridge enters Manitoba about one and a half miles we-

Blumenort and Kronsthal.

Carman.

which is situated upon it. Northward it passes about a mile west of Lowestoft post-office and a mile east of Carman. George Anderson's house is built on its crest in the N.E. ‡ of sec. 31, T. 6, R. 4, two mile north-northeast of Carman, at an elevation of about 965 feet. It cross the Canadian Pacific Railway near the Rat Creek bridge, and is well

elevation of its to the northeas arse is along of the chain of . which lie in se Gladstone this lacustrine silt, by a small beac imost due nor beach gravel an Grass Marsh th marsh being app this stage about The western incteen miles w he internationa Lowestort and th

developed along

passing through

of the Manitoba elevation of the porthwest of Ma havel and sand farther north it c of Elm Creek sta at 45 feet, from and seven feet in resses this sho Barnside, and in learly through th rile, the crest of two miles north ces ent from it of the southwest. Northwestern Ra Lafway between lo 862 feet above shore line is gene straceable on the the west shore of assing about half

hus lies near the

hie of the lake i

enemberg and Rheinland, and e to the south y an ascent of from its crest evel westward. ng land is fine y this beach is e delta, passing north of Bagot miles west of wind-blown in 929 feet aboyt and twelve to each ridge, also er east, with its hrough the east . 20, to the east

he Emerado and of erosion was boundary and a slight beach r in sec. 19, T.5 5, passing alon

and for several idge, having: o titty rods west et above the sea ccupies a width here is no note shallow pits du is shown tob rely a pebble i rds of an inchi half miles we 2, to Krons t a mile west orge Anderso R. 4, two miles

font. It crosses

dge, and is wer

developed along a distance of several miles thence to the northwest, massing through the southeast corner of sec. 12, T. 12, R. 9, where the elevation of its crest is about 875 feet, with a descent of four to six feet to the northeast and one to three feet to the southwest. Thence its amurse is along the southwest side of the Squirrel Creek marsh and east of the chain of Dead Lakes (a former channel of the White Mud River), which lie in sees. 17, 18 and 19, T. 14, R. 11. A half mile east of fladstone this shore is marked by a line of erosion in the expanse of Leastrine silt, with slope in a short distance from 882 to 875 feet, and Gladstone. by a small beach ridge of sand with its crest at 878 feet. Continuing almost due north, this Gladstone shore line, occasionally marked by leach gravel and sand, lies a half mile to one mile west of the Big Grass Marsh through Ts. 15, 16 and 17, R. 11, the elevation of the marsh being approximately 865 fee id of Lake Agassiz here during 45 stage about 875 feet above the present sea level.

The western Burnside shore enters Manitoba near Blumenort, incteen miles west of the Red River, but it is not distinctly marked on Burnside is international boundary. Passing northward about a mile east of hear Lowestoff and three miles east of Carman, it crosses the Carman beach the Manitoba & Southwestern Railway at Maryland, where the elevation of the crest of its beach ridge is 844 feet. About a mile northporthwest of Maryland this ridge has been extensively excavated, its navel and sand being used for railway ballast. One and a half miles arther north it crosses the main line of this railway about a mile west fElm ('reek station (the junction of the branch), its crest there being g 45 feet, from which its slopes fall ten feet in twenty-five rods east Maryland and and seven feet in an equal distance west. The Canadian Pacific Railway roses this shore about half-way between Portage la Prairie and Pariside, and in the next ten miles of its course, passing northwest gariv through the center of T. 12, R. 8, it is marked by a large gravel Near Burnside. like, the crest of which in the south part of sec. 11, one and a half to growiles north of Burnside, has an elevation of 858 to 860 feet, with es ent from it of six to ten feet northeastward and half as much to southwest. This beach is similarly prominent on the Manitoba & Northwestern Railway, by which it is crossed and excavated for ballast on the M. & N. alf-way between Westbourne and Woodside, its crest there being 860 W. Ranway 6 862 feet above the sea. Along the next forty miles the Burnside hore line is generally marked by a well developed beach ridge which is raceable on the plats of the Dominion Land Surveys parallel with he west shore of Lake Manitoba and four to five miles distant from it, song about half-way between the lake and the Big Grass Marsh. It has lies near the line between Rs. 9 and 10 as far north as to the east the of the lake in secs, 13 and 24, T. 18, R. 10, beyond which it runs "bnouthwest.

Eastern Burn-

Ts. 1 and 2, R. 4 E.

side beach. "The Ridge," Ridge " about eleven miles east of the Red River and Emerson, where it is marked by a low escarpment rising from 835 to 850 feet, consisting of till with frequent boulders, nearly all Archean, and by a deposit of gravel and sand a few feet deep, resting on the base of this slope, 833 to 840 feet above the sea. In the S.W. 1 of sec. 15, T. 1, R. 4 E., the Burnside beach is a typical gravel and sand ridge twenty to twenty-five rods wide; its crest is \$45 feet above the sea; and the descent from it to the east is about three feet and to the west six or seven feet. About a mile farther north, near the southeast corner of sec. 21, the elevation of this beach ridge is 844 feet, with a descent of one or two feet on the east and ten feet within twenty rods on the west. Another mile to the north its elevation is 846 feet, with two feet descent east and six feet west in six rods; next a surface of till, with many boulders, falls about five feet in forty rods to the west; beyond this a tract of grave and sand continues with the same slope, falling from \$35 to \$30 feet and is succeeded farther west by a slowly descending surface of it The beach ridge continues with similar features through the east half of sec, 28, excepting a short distance in the S.E. ‡ of this section, where it is replaced by a line of erosion in the very rocky till. Through is next three miles the uneven contour causes the beach ridge to somewhat imagular in its course and size; but it again attains it typical development in sec. 9, T. 2, R. 4 E., where it was excavate. several years ago along a distance of a third of a mile for railway ballast, a branch track nearly eight miles long being laid for its tracs. portation to Dominion City. The crest of the beach at Charles Aime, house near the north end of this excavation is 846 to 847 feet above the sea, with a decree of two to five feet on the east and six to eight feet in eight to and ods west. Its width, including both slopes, fifteen to thirty rods, and the maximum depth of the gravel and sadeposit is about eight feet, lying on till. The coarser portions of the gravel contain pebbles up to three inches or rarely six inches or more in diameter. Nine tenths or a larger proportion of them are magnesian limestone, the remainder being almost wholly Archean granite and gneiss. This shore line continues north and north-northeast by Green Ridge post-office and through the east part of Ts. 3 and 4. R. 4E. beyond which it has not been traced.

Proportion of lin.estone

> Between the south ends of Lakes Manitoba and Winnipeg the country about Shoal Lake was uncovered by the fall of Lake Agassiz from the Gladstone to the Burnside beach, which latter is crossed by Winnipeg & Hudson Bay Railway near the southwest corner of sec.

Burnside beach T. 14, R. 2, about three miles south of Shoal Lake. The crest of in vicinity of Shoal Lake. beach is 860 feet above the sea, being ten feet above Shoal Lake. Het

its course is from of till reaching three miles fart meses this bear mds south from ombined shore Igassiz. Westw width of one to west through the township it curv northwest between mentioned, the co 1 E., and T. 16, R

leach ridges not

between it and Sh

stage of Lake Ag

Ossowa post-off

evel.

R. 4. is situated of southwest to eastelevation from 84 snorth side and Pacific Railway w this beach, which naway cut its ma publies and subar is or eight inches Lagnesian limesto bullers, mostly I his timestone, wh north part of T. theast, and thei athe north half laces joining the appeamately para fit onward to Plea temble to this str mwhich a broad s early a quarter of . lings. Its cres eniving limestor ses the internat

Gert enters Min

ound at "The nerson, where eet, consisting y a deposit of this slope, 835 1, R. 4 E., the to twenty-five lescent from it n feet. About . the elevation wo feet on the nother mile to nt east and six · boulders, falls tract of grave 35 to 530 feet. surface of fi gh the east hah

s section, where Through the ch ridge to " gain attains A Was exeavale rile for railway at I for its trans-Charles Aimes S47 feet above and six to eight both slopes is gravel and so portions of t. inches or more i are magnesia an granite and theast by Green

peg the country of agassiz from the crossed by La borner of sec. A. The crost of ball Lake. He

and 4. R. 4E

is course is from west to east along the verge of a nearly level expanse of till reaching to the lake, to which its drainage is tributary. Two or three miles farther east, where the road to Stonewall and Winnipeg grosses this beach, it has a descent of twenty feet in thirty or forty reals south from its crest, the whole slope being gravel and sand, the ambined shore deposits of the Burnside and Ossowa stages of Lake Agassiz. Westward the beaches of these stages are separated by a width of one to two miles, the Burnside beach running southwest and west through the south half of T. 14, R. 3. Near the west side of this nownship it curves northward, and thence passes north and northnorthwest between Shoal and Manitoba Lakes. East of the road before mentioned, the course of this beach is northeastward across T. 15, R 1E. and T. 16, R. 2 E., to Pleasant Home post-office. Numerous short leach ridges noted on the township plats northwest of this beach, herween it and Shoal Lake, were probably formed during the Gladene stage of Lake Agassiz where the highest parts of that area rose above is level.

Osowa post-office, near the middle of the north half of sec. 27, T. L. R.4 is situated on a well defined beach ridge which runs from weekouthwest to east-northeast through this township. Its crest varies elevation from 843 to 848 feet, with descent of three to eight first ... snorth side and twelve to fifteen feet on the south. The Canadian Pacific Railway was originally constructed from Stonewall due west to this beach, which it cut through in the east edge of the 28. In the milway cut its material is wholly gravel, in part very coasse, containing publies and subangular rock-fragments up to four inches and rarely gor eight inches in diameter, of which fully ninefern twentieths are magnesian limestone. On each side the surface is all with plentiful onliers, mostly Archean granite and gneiss, but including many of his limestone, which is the underlying rock of the region. In the orth part of T. 13, R. 3, this beach curves to the south, east and theast, and thence passes through the southeast part of T. 14, R. 3. githe north half of T. 14, R. 2, gradually approaching and in some a. es joining the Burnside beach, with which the Ossowa beach is proximately parallel, lying a half mile to one or two miles southeast fit onward to Pleasant Home. The only other locality where a beach

merable to this stage was observed is on the top of Stony Mountai stage which a broad smoothly rounded ridge of gravel and sand extensionally a quarter of a mile and is the site of some of the Penitentiary millings. Its crest is about 835 feet above the sea, and the top of the salving limestone about 825 feet. The western Ossowa shore line less the international boundary a few miles east of Gretna, and the start enters Minnesota about three quarters of a mile west of "The

" ny Mour

Ridge," but they are not there marked by noteworthy beach deposits nor erosion.

Stonewall

The main street of Stonewall crosses a conspicuous beach ridge which runs from south-southwest to north-northeast a third of a mile or more. Its crest is 820 to 825 feet above the sea, and its depth is about ten feet Only two or three feet of till intervene between this gravel and sand and the underlying limestone, which, thinly covered by drift, rises in a swell here about twenty-five feet above the adjoining country a half mile distant to the east and west. Beach deposits belonging to this stage were not elsewhere observed, but they are doubtless traceable from Stonewali northward through the west half of Ts. 14 and 15, R.2 Lake Agassiz at the time of the Stonewall beach probably extended on the flat Red River Valley to a distance of about twenty-five miles south of the international boundary, being some fifteen feet deep at Emerson, Saint Vincent and Pembina, while over the site of Winnipeg its depth was about sixty feet.

Niverville

From Niverville to Otterburne

Morris.

The road on the east side of the Red River between Winnipeg and Emerson crosses a beach ridge about a half mile southeast of Nivervilla It has a width of fifteen rods, and its crest, 777 to 778 feet above the sea, is raised about four feet above the adjoining surface of lacustilla silt on each side. Beginning near Niverville station, it extends southeasterly at least a mile. Another beach ridge of similar size, will its crest at 780 feet, is crossed by this road a third of a mile farther south. This also runs southeast, holding its ridged form a mile more, beyond which it is less distinct. Again, a few miles to the south from these, a beach ridge extends along this road in a nearly due soul course across the S.E. 1 of sec. 17 and the east half of secs. 8 and 1 T. 7, R. 4 E. It rises two to four feet above the land adjoining on each side, which is partly sloughs with water throughout the year. elevation of the beach crest being 782 to 784 feet. Other beach deposits at nearly the same elevation occur a mile southwest Otterburne; a few miles farther to the south in the northeast part T. 5, R. 3 E.; and about a mile east of the Red River opposite to Morri West there of the southern end of Lake Agassiz in this stage near Morris, its westernies stage shore extended north and nontherest to the north and northeast to Little Stony Mountain five miles northwest Winnipeg, and thence nearly due north, passing between Stonewa and Stony Mountain and onward along the west side of Lake Winnig at a distance of a few miles from it. Gravelly and sandy deposits the base of Stony Mountain on its north and south sides are attributal. to erosion by the lake, there only a few feet deep, at the time formation of the Niverville beach. Its level was fifteen to twenty

above the surfa above Lake Wir All the beach Lake Agassiz, h ice-sheet, as is s Winnipeg and th present no barr original level of which the Nelson is probably that the mouths of th twenty-one feet of this shore lin around the whole

The Pembina d sixteen miles s or the stream of Lang's Valley, I mately with desirable to give s When the delta Muent from the received the drain bakatchewan reg minent delta c Agassiz by the Per e a maximum greeding 200 feet Grieet, About f. Thof the Pembi The most elevat 270 feet above th 8.5% east of the L early 300 feet al Les distant town ighest stage here e below this hig each line of this le

Agnitud of the Cana * 85 Chewar Explori seach deposits

ch ridge which in mile or more, about ten feet, ravel and sand a drift, rises in country a half longing to this tless traceable 14 and 15, R. 2 bably extended beauty-free miles on feet deep a ite of Winnipeg

Winnipeg at. st of Niverville 3 feet above to ce of lacustrias ion, it extents imilar size, wi: of a mile farth form a mile iles to the sour nearly due son of sees. 8 and 5 djoining on ea t the year, a t. Other bear le southwest ortheast par posite to Mor ons' sand. Fiprris, its west Starbuck, the les northwest tween Stonewa Lake Winnip andy deposits

s are attributal

at the tim-

n to twenty

giove the surface where Winnipeg is built and about seventy feet glove Lake Winnipeg.

All the beaches thus far described must be referred to the glacial Lake Agassiz, held on its northern side by the barrier of the waning icesheet, as is shown by Dr. Bell's description of the outlet of Lake Winnipeg and the topography of the adjoining country, which could present no barrier of land so high as the Niverville beach. The original level of Lake Winnipeg, due to the height of the land upon lake Winnipeg, which the Nelson River began to cut its channel in its present course, is probably that of the well defined beach observed by Hind between the mouths of the Winnipeg and Red Rivers, having "an elevation of twenty-one feet above the present level of Lake Winnipeg."* Traces of this shore line will probably be found at nearly the same height would the whole lake.

DELTA OF THE PEMBINA RIVER.

The Pembina delta lies wholly in North Dakota at a distance of four asixteen miles south of the international boundary; but its deposition by the stream outflowing from the Lake Souris along the course of Lag's Valley, Pelican Lake, and the Pembina, associates it so imately with this glacial water-course in Manitoba that it seems assimble to give some description of it here.

When the delta was deposited, the Pembina was swollen by a great stant from the glacial Lakes Saskatchewan and Souris, and thus needed the drainage from the melting ice fields of the Assimiboine and statchewan region far beyond the present limits of its basin. The reminent delta of gravel and sand brought into the margin of Lake kassix by the Pembina extends twelve miles from north to south and Extentan is a maximum width of seven miles, with a maximum thickness, as a maximum width of seven miles, with a maximum thickness to feet. Its average thickness is probably not less than before. About five sixths of its area of fifty square miles or more lies of the Pembina River, reaching nearly to the Tongue River.

The most elevated point of this delta, as it now remains, is about 550 feet above the sea, near the northwest corner of sec. 11, T. 162, R. ast of the Little Pembina and south of the Pembina River, and issarly 300 feet above the junction of these streams, one and a half also distant toward the northwest. The level of Lake Agassiz in its lighest stage here was 1,220 or 1,225 feet above the sea, being fifty the Pembina class within highest part of the Pembina delta, as is shown by the fifty feet above at line of this level, 1,226 feet, in the central part of sec. 7. T. 162, the upper beach line of this level, 1,226 feet, in the central part of sec. 7. T. 162, the upper

Varitive of the Canadian Red River Exploring Expedition of 1857, and of the Assinibate easier even Exploring Expedition of 1858, vol. i, p. 122.

R. 56, where an eastward descent begins. This is the east verge of the nearly flat area of the delta in secs. 12 and 7. Like all of this vast delta deposit, the material here is sand and gravel, covered by a fertile soil. A small proportion of the pebbles of this gravel is limestone; a large part is Cretaceous shale; but more was derived from Archæm formations of granite and gneiss.

On the road from Olga to Walhalla the crest of the east margin of this delta is crossed in the north part of sec. 33, T. 163, R. 56, about two miles southeast from Walhalla. Its elevation is 1,190 to 1,196 feet above the sea. This is a beach accumulation, belonging to the third Herman stage. Toward the west and southwest the undulating delta plateau, mostly covered with bushes and occasional trees, is te to thirty feet lower for a width of one to one and a half miles averaging about 1,175 feet. Northeast from the crest of this road; short descent is made to a prairie terrace 30 to 60 rods wide, varying in elevation from 1,182 to 1,169 feet, but mainly within two feet above or below 1,175. In general the verge of this terrace is its lowest portion. Thence a very steep descent of 169 feet is made on the road from 1,173 to 1,004 feet, this being the very conspicuous woode escarpment called the "first Pembina Mountain." It is the croder front of the great Pembina delta, the eastern part of which, original descending more moderately, has been swept away by the waves and

shore currents of the lake during its Norcross, Tintah, Campbell, and

McCauleyville stages. From this sec. 33 the "first mountain" extends

southeast to secs. 13 and 24, T. 162, R. 56, and northwest across the

Pembina, passing close southwest of Walhalla and onward to sees, by and 3, T. 163, R. 57. Its highest part is intersected by the Pembina

River, above which it rises on each side in bluffs of gravel and said 200 to 250 feet high, with their crests a half mile to one mile apar.

From this upper portion the delta slopes down gradually toward is southeast and toward the northeast and north, extending only two p

four miles north of the Pembina.*

First Pembina Mountain.

Sources of the gravel.

In the gravel of this delta, as seen in the bluffs of the Pembina near Walhalla and at noteworthy springs two miles to the south on the

*The first Pembina Mountain was visited by D. D. Owen in 1848. He describes it as follows—
"Pembina Mountain is, in fact, no mountain at all, nor yet a hill. It is a terrace of table hat he ancient shore of a great body of water that once filled the whole of the Red River Vals;
On its summit it is quite level and extends so for about five miles westward to another terms
the summit of which I was told is level with the great buffalo plains that stretch away rount
the Missouri, the hunting grounds of the Sioux and the half-breed population of the Red River
—Report of a Geological Survey of Wicconsin, Iowa and Minnesota, 1852, p. 178.

Both the first and second Pembina Mountains were examined in 1867 by Palliser, who says the flat Red River Valley and the Pembina delta:—"This plain, no doubt, had formed—interest to be do for a sheet of water, and the Pembina Hill, consisting of previously deposits materials, was its western shore."—Journals, detailed reports, &c., presented to Parliament, if May, 1863, p. 41.

. raav. 7

south side of t hale, of other dark trappear nearly equal re in the same be erosion of its at and was oceasi materials; but the overlying moss agute are landed agates v water-wearing. delta gravel at leds of this kin fragments is no this region and The deposition stage of Lake A of sediments be Valley they wer more than fifty iesheet caused permitted the So this delta cease

of this first Peml swept southward. ther were deposi he Tongue River west of Cavalier. ecumulated, muc wer, were carrie central part of the mount nearly a raches across the But on the west of holably because oth south and no orth to Gardar a om two miles no nd onward.

channels out thro

of the steep escar

st verge of th. all of this vast red by a fertile s limestone; :. from Archæan

east margin of

R. 56, about two 0 to 1,196 feet ng to the third the undulating nul trees, is te: a half miles, t of this road a s wide, varying two feet above ce is its lower ade on the roal picuous woode. It is the crode: vhich, originally the waves and a, Campbell, and untain" extent west across th ward to sees, ! by the Pembina gravel and sait one mile apar. ually toward the

ne Pembina near he south on the

ling only two to

scribes it as followa terrace of table la the Red River Valley ard to another term t stretch away towar tion of the Red Reco

by Pulliser, who so bt, had formed d of previously depart ted to Parliament

south side of the river, the pebbles of some beds are mainly Cretaceous shale, of others mostly limestone, and of others granite, gneiss, and lark trappean rocks. In the aggregate, these three classes have a nearly equal representation; and they are more commonly intermingled in the same beds. The shale was doubtless chiefly derived from the prosion of its strata along the glacial water-course from the Lake Souris, and was occasionally deposited in layers almost unmixed with drift materials; but the other constituents of the gravel were derived from the overlying drift and from the melting ice-sheet. White quartz and moss agate are frequent, and bits of silicified wood occur rarely; but no landed agates were found. Numerous pieces of lignite, rounded by Fragments of water-wearing, from two to four inches in diameter, noticed in this lignite. delta gravel at the springs, have caused some to look for workable leds of this kind of coal in the vicinity; but the proportion of these fragments is no greater than in the glacial drift generally throughout this region and for hundreds of miles to the south.

The deposition of this delta took place during the highest Herman Time and gage of Lake Agassiz. It seems to have been very rapid, the supply deposition. sediments being so great that about the mouth of the Pembina Valley they were accumulated in a fan-like sloping mass to a height of more than fifty feet above the lake level. When the recession of the mesheet caused the cessation of its supply of modified drift, and remitted the Souris to flow as now to the Assimiboine, the growth of his delta ceased; and its subsequent history is that of the deep channels cut through it by the Little Pembina and the Pembina, and of the steep escarpment sculptured on its east side. From the erosion Erosion and g his first Pembina Mountain large amounts of gravel and sand were redeposition. stept southward, notably during the Campbell stages of the lake, when they were deposited in a very massive curving beach ridge that crosses he Tongue River in the west part of T. 161, R. 55, about seven miles mestor Cavalier. In the Herman stage, while the delta was being comulated, much fine clay and silt, brought by the same glacial Lacustrine silt wer, were carried farther and spread upon the lake bed along the and areas of entral part of the Red River Valley, perhaps extending in appreciable mount nearly a hundred miles southward to the belt of till that eaches across the valley at Caledonia and forms the Goose Rapids. but on the west edge of the lacustrine area this fine sediment is absent, pobably because of currents trending off shore; and the surface is till sch south and north of the gravel and sand delta, as from Park River orth to Gardar and Mountain and nearly to the Tongue River, and on two miles north of the Pembina to the international boundary d onward.

Extent and houndaries.

DELTA OF THE ASSINIBOINE RIVER.

At Brandon the Assiniboine enters the area of Lake Agassiz, and thence the gravel and sand delta of this tributary extends eastward seventy-five miles to Portage la Prairie, northeastward fifty miles to Gladstone, and east-southeastward eighty miles to Almasippi peroffice, nine miles west of Carman. On the northwest this delta . bordered by an expanse of moderately undulating or rolling till which rises slowly above the ancient lake level and stretches northwestwafrom Brandon, Chater and Douglas to the Little Saskatchewan and Oac Rivers. From Brandon to Douglas the boundary of the delta is else north of the Assiniboine and the Canadian Pacific Railway; but a Douglas the line dividing the delta sand and gravel and the adjoining surface of till turns north-northeastward and extends about twent miles in a nearly direct course toward Neepawa, then bends northwain the east part of Ts. 13 and 14, R. 16, and crosses Stony Creek a te miles west of Neepawa. Between Brandon and the mouth of the Souris the delta reaches three or four miles southwest of the Assimilaria being there also bordered by a smoothly undulating or rolling tractill, but the morainic Brandon Hills rise prominently within and miles farther west. From the Souris east to the Cypress, a distance nearly twenty-five miles, the southern margin of the delta is similar divided from the Tiger Hills by a belt of undulating and rolling which averages about five miles in width. Farther to the east delta deposits abut directly upon the northern base of these hills to Cypress River by Holland and Treherne to the north end of Pembina Mountain. Thence to the southeast the head streams of Boyne, after their descent from the plateau of the Pembina Mounts cross the southeastward extension of this delta to Almasippi. portion, however, is not probably a part of the delta as it was at: deposited, but has been derived from the erosion of the eastern as of the original delta by the waves of the lake in its later of successively lower stages, being transported thence southward by significant currents. The same lacustrine action has doubtless extended the dela of gravel and sand generally five to fifteen miles eastward beyon original area, thereby giving its eastern face a more gradual -As thus enlarged, its east boundary runs north from Almasique Portage la Prairie, curving eastward between these places; and the it passes west-northwest to near Gladstone, Arden, and Neepawa. eastern base of the delta, where it adjoins the flat expanse of the la River Valley and the country bordering the lower Assiniboine Lake Manitoba, has an elevation of 850 to 900 feet above the while the high delta plateau, which was submerged only about if

, r-496-

feet or less by shoals and low the sea. The already noted, from Treherne about 1.300 squ thirds as mucthan 2,000 square

The thickne which general within modern oralities, howe through the de and wells mus Better measures applied by the ac eroded in th adta plateau be especially nume serings issue ner and beds and t Creeks which flo 10 to 300 feet n ata is a further a the verge of th leis on the Assi stagravel and rages from 100 te greater part takness of this esenty-five feet. ... area of 2,000

Fifty miles east surface of the delay where it has not 1240 feet above the star the centre of sestward, between the control of the central part of

Agassiz, and

end- eastwart

fifty miles t-

Imasippi post.

t this delta .

lling till which

northwestwa

newan and Oas

e delta is clas

ailway: but a

d the adjoining

about twents

ends northwar

ny Creek a 1

mouth of t.

'the Assinibal'

r rolling tract

ly within at

ess, a distance delta is similar

g and rolling

to the east f these hills too

worth end of

ad streams of t mbina Mount.

Almasippi. T

as it was at: the eastern it !

in its late:

uthward by si xtended the de

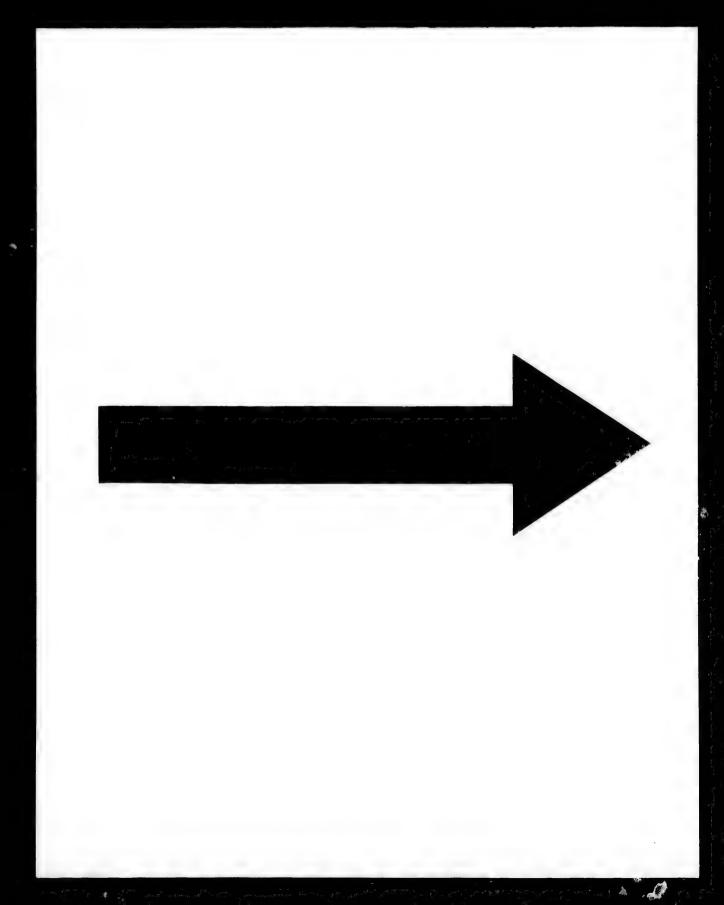
stward beyond re gradual -

om Almasipa.

het or less by the lake when it was being deposited, and was in part High plateau shouls and low islands, has an elevation from 1,200 to 1.275 feet above slope of the the sea. The western and southern limits of the plateau are those of each. already noted, and on the east its boundary runs north and northwest from Treherne to Sydney and Neepawa. The area of the plateau is shout 1,300 square miles, and the eastern slope adds to this fully two hirds as much, making the total area of this delta somewhat more than 2,000 square miles.

The thickness of the Assiniboine delta is seldom shown by wells, Thickness and which generally obtain a plentiful supply of water upon this area within moderate depths, ranging from ten to fifty feet. In some oralities, however, near the great valley that the Assiniboine has cut through the delta, the plane of saturation probably lies much deeper, and wells must be sunk a hundred feet or more to obtain water. Better measures of the depth of these gravel and sand deposits are applied by the valleys of the Assiniboine and other streams, which are groded in their deeper portions 100 to 200 feet below the top of the pla plateau before reaching the underlying till. Deep ravines are especially numerous on the northern part of the delta, where many springs issue near the plane of junction between the porous gravel and and beds and the till, giving rise to the Squirrel. Pine and Silver creks which flow northeast to the White Mud River. The descent of 19110 300 feet made within a few miles upon the eastern face of the lea is a further indication of its thickness, which reaches its maximum at the verge of the plateau. In the vicinity of the outcrop of Niobrara hels on the Assiniboine in sec. 36, T. 8, R. 11, the thickness of the Magravel and sand appears to be about 200 feet; and it probably ranges from 100 to 200 feet along the outer limit of the plateau through te greater part of its extent of more than fifty miles. The average k-kness of this very extensive delta is probably between fifty and eventy-five feet. Computing its volume for an average of fifty feet on harea of 2,000 square miles, it is found to be about twenty cubic

Fifty miles east-southeast from Brandon the highest portions of the reace of the delta south of the Assiniboine and east of the Cypress, the plateau of the Assiniboine where it has not been heaped in sand hills by the wind, are 1,225 to deta. 1340 feet above the sea, the latter being its elevation in a broad swell ear the centre of sec. 24, T. S, R. 11. Ten to twenty miles thence laces; and them d Neepawa. 11 restward, between Cypress River and Glenboro, the elevation of the xpanse of the legislity undulating surface of the delta is mostly 1,235 to 1,245 feet,
Assimboine at sith frequent sloughs and permanent ponds, up to a quarter of a mile
et above these emore in extent, lying at 1,225 to 1,235 feet. These nonds abound d only about all lear Glenboro and for four miles east. Along the Canadian Pacific



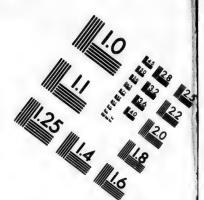
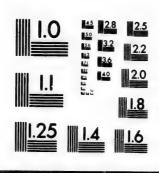


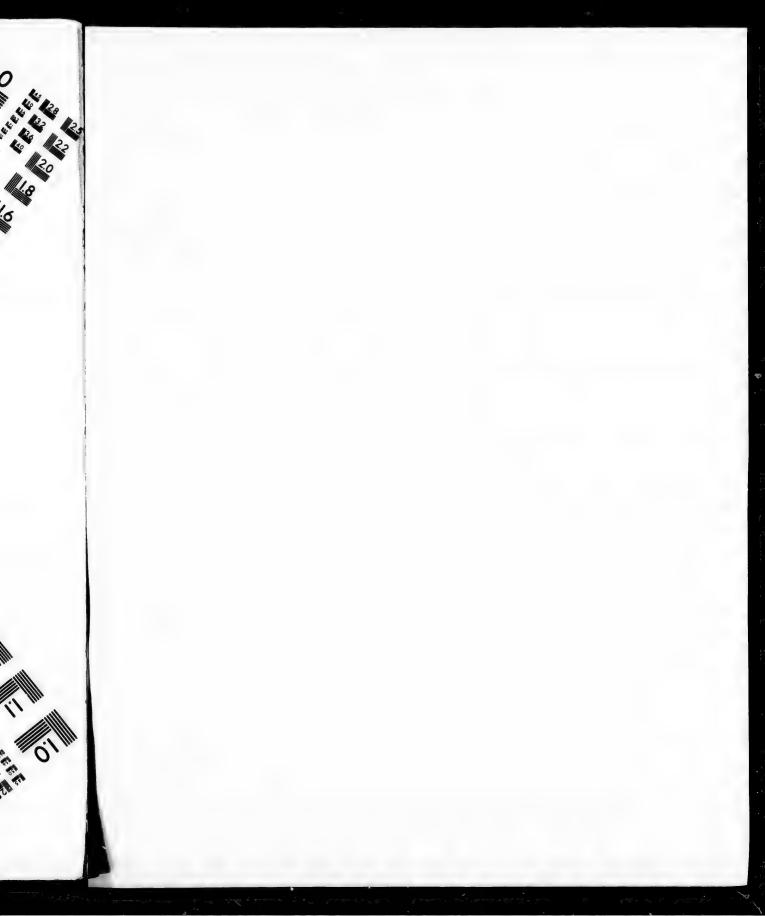
IMAGE EVALUATION TEST TARGET (MT-3)



Photographic Sciences Corporation

23 WEST MAIN STREET WEBSTER, N.Y. 14580 (716) 872-4503

STATE OF THE PARTY OF THE PARTY



Railway from Sydney westward by Melbourne, Carberry, and Sewell. to Douglas, twenty to twenty-five miles north of the foregoing, the undulating delta ranges in elevation from 1,230 to 1,275 feet; and it holds the same height through twenty-five miles northward, to within three miles southeast of Neepawa. Adjoining the undulating and rolling area of till which borders this part of its area on the west, its expanse of gravel and sand slowly rises northward from 1,265 and 1,270 feet two to three miles northeast of Douglas to 1,275 and 1,280 feet between Willow or Boggy and Spring Creeks. These elevations represent the plateau before mentioned, which forms the greater part of this delta. While the extensive area of this plateau, reaching fifty miles from

east to west and nearly the same distance from north to south, is thus so uniform in its elevation that its deposition must be attributed to stages of the lake when its level was not much higher, probably those of the Herman beaches b and bb near Treherne and Necpawa, there is Highest portion a considerable tract lying on both sides of the Assiniboine in the of this delta in vicinity of Brandon and Kemnay, upon which delta deposits closely Brandon and

North of the Assiniboine.

in a distance of twelve or fifteen miles from east to west. A mile north of Brandon the bluff on the north side of the Assiniboine rises about 140 feet above the river to 1,300 feet, approximately, above the sec. It consists of till to a height of 100 feet or more; but its crest and the surface thence northward for five miles is mostly undulating gravel and sand to a thickness of 10 to 20 feet, thinly covering the till, which forms the surface farther north. Eastward this bluff, eroded by the Assiniboine since the deposition of this stratified gravel and sand extends along the north side of the railway by Chater and Douglas having a height of about 75 and 50 feet, respectively, at these stations but declining only slightly in the elevation of its crest, which is 1.25 to 1,290 feet. Delta gravel and sand, and on some portions fine silt, cover a width of three or four miles thence northward through the south half of Ts, 11 of Rs, 18 and 17, having an elevation at their northern limit 1,300 to 1,290 feet above the sea, beyond which the surface, gradually ascending northward, is till. The most eastern point of this higher delta deposit is in sec. 14, T. 11, R. 17. Measured thence to its western limit on the north side of the Assiniboine half-way between Kemnay and Alexander, its length is twenty-four miles. width north and south of Brandon is about twelve miles. Through the Assiniboine has eroded its valley, and has carried it away, cutting also into the underlying till, upon a large area from Brandon east Chater and Douglas and thence south nearly to the Brandon Hills.

South of the river, at the court house in the southeast part of Brandot

diameter, forn rising to 1,28 half to three r from 1,290 to which slope continuous, a 1 of a mile in w through the so three miles, or area eroded b 1.250 feet to 1, of the formation of Lake Agass miles west of course of simil ahalf mile in passing from t associated with this plateau ascend from a few feet to 125 feet above it Creek. Its bed the erosion her till, is about 1, b stage of Lak below the adjo west. In three to 60 feet, and a half miles to Thence the sur including near west, is till. Many portio have been char

CPHAM.

very course g

delta, contain

feet high, mostl plants, but in p obtaining a foot of this area the occur in secs. upon a width of Assiniboine. • dunes extend t

Both these trac and thence wes slope. Even w ry, and Sewell. foregoing, the 75 feet; and it ward, to within undulating and on the west, its from 1,265 and 1,275 and 1,280 Chese elevations the greater part

fifty miles from to south, is thus be attributed to r, probably those lecpawa, there is siniboine in the deposits closely 125 feet above it st. A mile north boine rises about y, above the ser. t its crest and the andulating gravel ng the till, which ff, eroded by the gravel and sand, ater and Douglas, at these stations est, which is 1,275portions fine silt ward through the elevation at their beyond which th most eastern poin R. 17. Measure siniboine half-way ty-four miles. niles. Through i d it away, cutting n Brandon east Brandon Hills. st part of Branden

very coarse gravel and sand of this higher part of the Assiniboine delta, containing water-worn cobbles up to six and eight inches in diameter, form a plateau mostly 1,270 to 1,275 feet above the sea, but rising to 1,282 feet at a distance of one mile to the east. One and a half to three miles west of Brandon, a similar plateau varies in height South of the from 1,290 to 1,305 feet. Between these small plateaus or plains, Assiniboine. which slope about five feet per mile to the east and were once continuous, a former water-course, diminishing from a half to a quarter of a mile in width, passes southeast from the valley of the Assiniboine through the south part of Brandon and thence continues east nearly three miles, opening in sec. 7 or 8, T. 10, R. 18, upon the broad lower area eroded by the Assiniboine. The bed of this old channel is at 1250 feet to 1,255 feet, and it appears to have been eroded at the time of the formation of the Herman beach bb in Brandon, when the level cours of Lake Agassiz was approximately at this height. Three to four miles west of Brandon, the road to Kemnay crosses another watercourse of similar character, diminishing from one and a half miles to shalf mile in width within two miles from northwest to southeast, massing from the Assiniboine Valley to the head of Baker's or Stony treek. Its bed, which is strewn with plentiful boulders, showing that the erosion here extended through the stratified gravel and sand to till is about 1,270 feet above the sea, and marks nearly the Herman stage of Lake Agassiz, being about 30 and 40 feet, respectively, below the adjoining areas of delta gravel and sand on the east and west. In three miles westward to Kemnay this delta expanse rises 50 to 60 feet, and continues to ascend more slowly in the next three and shalf miles to 1,390 and 1,400 feet in secs. 1, 12, and 13, T. 10, R. 21. Thence the surface for the next six miles westward about Alexander, including nearly all of this township and the east edge of that next west, is till.

Many portions of the fine sand deposits of the Assiniboine delta have been channelled and piled by the wind in dunes from 10 to 75 feet high, mostly covered with bushes and a scanty growth of herbaceous plants, but in part destitute of vegetation, which is prevented from obtaining a foot-hold by the drifting of the sand. On the southeast part of this area these sand hills, seldom exceeding 30 or 40 feet in height, occur in secs. 1 to 4, T. 7, R. 7, and are thence frequent northward upon a width of ten miles northeast of the Boyne and southeast of the Assiniboine. On the north side of the Assiniboine the most eastern dunes extend to within three miles southwest of Portage la Prairie, Both these tracts lie on the lower part of the eastern slope of the delta, and thence westward dunes are found here and there over this entire slope. Even where no distinct hillocks and ridges have been formed,

Tracts of

the surface is often channelled and ridged in hollows and elevations of a few feet, though now wholly grassed or covered with bushes or small poplar groves. Upon the delta plateau tracts of dunes, commonly raised 20 to 40 feet above the general level, interspersed with occasional smooth areas where the original surface remains undisturbed, extend on the south side of the Assiniboine from the Cypress to the Souris, occupying a width that varies from one to five miles. Their southern limit is about four miles north of Holland. three miles north of Cypress River station, and two miles north of Glenboro. One to four miles west of the mouth of the Souris, an isolated tract of dunes about three miles long from southeast to northwest is crossed by Spring Creek near its mouth. North of the Assiniboine much of its delta plateau is occupied by dunes, which extend north to the White Mud River. Their most northern area is a belt that reaches north of this stream through secs. 12, 13, 24 and 25 T. 15, R. 15, to the junction of Hazel and Snake Creeks. But the northwestern part of this plateau includes a belt of smooth and fertile land, several miles wide, extending from Carberry north and northwest to the limit of the delta. Also, from Douglas and Chater southeastward a belt of good agricultural land, free from dunes upon a width of three to five miles, reaches fifteen miles along the northeast side of the Assiniboine. On the extreme western and highest part of this delta conspicuous sand hills rise 60 feet above the adjoining surface, with their crests about 1.445 feet above the sea, in secs. 6 and 7, T. 10, R. 20, two to three miles southwest of Kemnay; and lower hillocks of wind-blown sand continue from these two miles to the southeast.

Delta and dunes of La Souris in th vicinity of Griswold.

Within six miles west from the dunes last noted and from the Lake boundary of this Assiniboine delta, after crossing a belt of till that reaches about three miles east and the same distance west from Alexander station, the Canadian Pacific Railway thence west to Griswold, Oak Lake and Virden, lies upon the delta which was brought into the Lake Souris by the Assiniboine. In Ts. 9 and 10, R. 22, and T. 9, R. 23, including the vicinity of Griswold, this deposit consists of fine clayey silt and sand, having a moderately undulating or rolling surface with broad smooth swells elevated 10 to 30 feet above the depressions, their tops being 1,400 to 1,435 feet above the sea. Three to seven miles southwest of Griswold this delta has been much channelled and uplifted by the wind in sand hills, which thence continue ten miles southeast along the north side of Plum Creek to sec. 11, T. 8, R. 22, four miles west of Plum Creek village. The crests of these dunes are 1,420 to 1,430 feet above the sea, being 30 to 40 feet above the adjoining surface. Nearly all of them are now covered by grass and bushes.

z-AV.

An ancient the Big Sloug wide, but in it from southwe: Souris and the Its west end about half a n anth side of t water ranges varies from tw rise in gentle s the general lev by streams; outflowed at or lake north of t the opposite di Brandon glacia the departure of this channel, to great glacial Souris outflowe Pembina Rive: Tiger Hills and the Souris, out ne Souris now Brandon Hills, during its rece utflowing wes Shugh. As soc Hills wholly un were merged in south through t it down nearly east and north Lake Agassiz, lake by the re Hills, received portion of the Kemnay, consi ie and partly o east from the L

the latter is spre

Kemnay, and up

An ancient water-course, now occupied by a body of water called

r-AV.

d elevations of with bushes or acts of dunes. el, interspersed urface remains boine from the from one to five rth of Holland. miles north of the Souris, an m southeast to North of the y dunes, which orthern area is a 2, 13, 24 and 25, reeks. But the nooth and fertile h and northwest er southeastward width of three to ast side of the art of this delta, ng surface, with and 7, T. 10, R. ower hillocks of

southeast. d and from the belt of till that ance west from thence west to elta which was Ts. 9 and 10, R old, this deposit ately undulating ed 10 to 30 feet feet above the is delta has been lls, which thence f Plum Creek to age. The crests being 30 to 40 are now covered the Big Slough, thirteen miles long and mostly twenty to fifty rods connection wide, but in its west part about three-fourths of a mile wide, extends Souria and mon southwest to northeast nine miles through this delta of Lake Agassiz by Souris and thence continues four miles east through an area of till. Its west end is two miles southwest of Griswold, and its east end shout half a mile east of Alexander, its whole extent being on the outh side of the railway. Its elevation in the stages of low and high water ranges from 1,385 to 1,388 feet, and its depth at low water varies from two to six or eight feet. The shores of the Big Slough rise in gentle slopes fifteen to twenty feet in twenty to thirty rods, to the general level, not having the usual steepness of banks undermined by streams; yet it doubtless marks the course of a stream that nutflowed at one time westward into Lake Souris from a small glacial ake north of the Brandon Hills, and of a later stream that flowed in the opposite direction, eastward from the basin of Lake Souris into the Brandon glacial lake, before that became merged in Lake Agassiz by the departure of the ice-sheet. The succession of events indicated by his channel, together with that of the present Souris and with the meat glacial water-course of Lang's Valley, is as follows. Lake Souris outflowed eastward by Lang's Valley, Pelican Lake, and the Pembina River, until the receding ice formed a lake north of the Tiger Hills and east of the Brandon Hills, which, outflowing south to the Souris, cut a deep gorge through the Tiger Hills moraine, where the Souris now flows through it to the north. Similarly, north of the Brandon Hills, a lake was probably held by the barrier of the ice bring its recession from Alexanove east by Kemnay and Brandon, unlowing westward to the Lake Souris by the course of the Big Sough. As soon as the continued glacial recession left the Brandon Hills wholly uncovered from the ice, these lakes on the east and north were merged in one, and the outflow from the lake so formed passed south through the Tiger Hills to Lang's Valley until that channel was t down nearly to 1,350 feet. During this stage of a continuous lake east and north of the Brandon Hills, this independent part of Lake Agassiz, before it was merged with the main body of this lake by the recession of the ice from the east end of the Tiger Hills, received an extensive delta, already described as the highest portion of the Assiniboine delta in the vicinity of Brandon and Kemnay, consisting partly of modified drift from the retreating ite and partly of fine sand and silt brought by a stream then flowing east from the Lake Souris delta along the Big Slough. The tribute of the latter is spread over an area of several square miles southwest of Kennay, and upon it are raised the conspicuous dunes of secs. 6 and

7, T. 10, R. 20. With the retreat of the ice northward from Treherne the Brandon lake was lowered nearly 100 feet to the level of Lake Agassiz ... its Herman b stage. For a short time the Souris probably continued to flow southeastward through Lang's Valley until the deposition of the alluvium, perhaps ten or fitteen feet thick, brought into that valley by Dunlop's Creek four miles east of the Elbow of the Souris, raised a barrier a few feet higher than the gap that had been cut through the Tiger Hills north of the Elbow, whereby the river was turned through this gap, which it has since eroded 100 to 150 feet deeper.

The modified drift and alluvium that form the plain of coarse gravel and sand sloping eastward from Kemnay to Brandon and reach along the north side of the Assiniboine to Douglas, were probably deposited mostly while the barrier of the waning ice-sheet stretched from the Tiger Hills to Riding Mountain, enclosing on its west side a lake that afterward became the bay of Lake Agassiz covering the Assiniboine

History of the formation of the Assiniboine delta.

delta, but was then held about a hundred feet above Lake Agassiz, to which it outflowed by the way of Lang's Valley and the Pembina The deposition of this highest part of the Assiniboine delta, lying above the Herman bb beach observed in Brandon, appears to have been in progress through a considerable period, beginning when this Brandon glacial lake was held at an elevation of about 1,400 feet, and continuing while it was lowered nearly 150 feet. During this time the Brandon lake had three outlets: first from its two parts respectively westward by the Big Slough and southward across the Tiger Hills moraine; second, from the whole lake, when these parts became confluent by the southward one of these outlets, namely, the gap where the Souris now flows through the Tiger Hills; and third by confluence with Lake Agassiz, when this was permitted by the recession of the ice. Much modified drift was probably brought into the Brandon lake by drainage along the course of the Little Saskatchewan; and it is significant that in the line of continuation of the valley of that stream the plain between Kemnay and Brandon is crossed by a broad water-course, which was evidently eroded after this lake became merged in Lake Agassiz, thereby falling nearly a hundred feet below its former level when outflowing through Lang's Valley, but before the Assinboine had cut its broad valley through this delta. More exactly, as before noted, this water-course seems referable to the Herman b stage of Lake Agassiz; and the similar water-course about twenty feet lower, passing through the west and south parts of Brandon, was probably formed during the Red River Valle Herman bb stage. During these two stages of the lake the principal siles east souther expanse of the Assiniboine delta was formed, lying only slightly below mastrine sedimthe levels which the lake then had.

At the time had already e and as Lake continued, cut ann feet deep, channel to a n Pacific Railw Reandon, near Agassiz and th

on each side of

he made by ea

slope south of favorable poin west, where th greater part of ice-sheet on th Riding Mount Ried Tail Cree was deposited

of the lake, as

principal expa

was melted av

The erosion of

considerable pa

Agassiz, to tho delta was under which its outer farther into the shore. By this erosi earlier transpor and sand were b Tiger Hills an

ediment of the

extending to the

he internationa

ill from the ea lefined, to the ast of Emerson he Assiniboine o

from Treherne. e level of Lake Souris probably alley until the t thick, brought he Elbow of the p that had been ereby the river 1 100 to 150 feet PHAM.

of coarse gravel and reach along obably deposited retched from the t side a lake that the Assiniboine Lake Agassiz, to nd the Pembina delta, lying above to have been in hen this Brandon et, and continuing time the Brandon ectively westward r Hills moraine: ame confluent, by where the Souris fluence with Lake of the ice. Much a lake by drainage is significant that the plain between course, which was in Lake Agassiz ormer level when

At the time of formation of the Herman bb beach, the Assiniboine Channel of the had already eroded a deep and wide valley in its delta at Brandon: and as Lake Agassiz sank to successive lower levels this erosion continued, cutting at least the lower part of the great valley, 200 to 200 feet deep, in which this river flows above Brandon, and wearing its channel to a nearly equal depth through its own delta. The Canadian Pacific Railway crosses the Assiniboine about two miles east of Brandon, near the division between the main area of its delta in Lake Agassiz and the deep portion of its upper valley. There the high land on each side of the river recedes, allowing the descent to the stream to he made by easy grades on each side, and supplying upon the gradual slope south of the river the beautiful site of Brandon. No other so favorable point for this crossing exists within sixty miles to the east or west where the river flows in a deeper and narrower valley. The greater part of this delta was modified drift derived from the molting ice-sheet on the upper part of the basin of the Assiniboine and on Riding Mountain, being carried down from the latter area by the Birl Tail Creek and the Oak and Little Saskatchewan Rivers. It was deposited in this delta chiefly during the early Herman stages of the lake, as is indicated by the elevation of the outer part of its principal expanse; and its deposition continued until the ice-sheet was melted away on Riding Mountain and the upper Assiniboine. The erosion of the Assiniboine Valley above Brandon also supplied a considerable part of the delta. During the ensuing stages of Lake Agassiz, to those of Gladstone and Burnside, the border of this great delta was undergoing erosion by the lake waves and shore currents, by Erosion by which its outer portion was spread in more gentle slopes, extending arther into the lake, and much of it was swept southward along the shore.

By this erosion of the sloping face of the delta, and especially by earlier transportation into the deep water of the lake while the gravel and sand were being deposited in its western embayment between the figer Hills and Riding Mountain, a large expanse of fine clayey ediment of the same origin with this delta was spread far into the lake, extending to the east beyond the Red River and to the south beyond ssinboine had cut the international boundary. This deposit of lacustrine silt covers the Lacustrine silt before noted, this ill from the eastern and southeastern limits of the delta, as before of Lake Agassiz; defined, to the low ridge first east of the Red River, about ten miles , passing through set of Emerson, while similar sediments cover the central part of the ormed during the Bel River Valley southward to Goose Rapids, more than a hundred ake the principal siles east southeast from this delta. Toward the north and northeast nly slightly below mustrine sediments and subsequent alluvial deposits associated with le Assiniboine delta cover the nearly flat country north from Burnside,

Between Portage la Prairie and Lake Manitoba

Portage la Prairie and High Bluff to Lake Manitoba. On this area the water-shed between the Assiniboine and Lake Manitoba is very low, and the river has sometimes overflowed its low banks, sending part of

Lake Manitoba, its floods north to the lake, which in turn in its highest stages has occasionally become for a short time tributary to the lower part of this river. But the transportation of the silt in the lake was of less extent Adjoining areas in this direction than to the east and south, as is shown by areas of till of till.

on both sides of the Big Grass Marsh west of Lake Manitoba, and from Ts. 13 and 14, R. 5, southeast of this lake, eastward to Shoal Lake. Stonewall, and Selkirk.

Projecting

Five to ten miles west of Portage la Prairie till with frequent boulders forms the surface, or is only overlain to the depth of a tew feet by the sediments associated with this delta. Again, ten miles farther west, the sandy eastern slope of the delta in the vicinity of McGregor shows very rarely projecting boulders, the size of the few noticed being from two to six feet in diameter. They probably lie on till that has been somewhat eroded by the lake waves, so that these boulders are not embedded in it as usual, while the sand and silt afterward spread there on the surface are not sufficiently thick to conceal them. No boulders were elsewhere seen on the general surface of the delta and of the great area of associated lacustrine silt, nor in any observed sections of these deposits.

CHANGES IN THE LEVELS OF THE BEACHES.

The successive shore lines of Lake Agassiz are not parallel with each other and with the present levels of the sea and of Lakes Winnipez and Manitoba, but have a gradual ascent from south to north, which is greatest in the earlier and higher beaches and slowly diminishes through the lower stages of the lake, being at last only slightly different from the level of the present time. On the west side of Lake Agassiz the elevations of its beaches have been determined by continuous leveling, referred to sea level by railway surveys, through a distance of more than 300 miles from its mouth at Lake Traverse northward to near Riding Mountain in Manitoba; and the accompanying table shows approximately the stages of the lake during the formation of these shore lines, in their relations to each other and to the present level. These stages of the water surface have been assumed to coincide generally with the foot of the lakeward slope of the beach ridges, and with the base of eroded shore escarpments, the crests of the beaches having had a variable height from five to fifteen feet above the lake, corresponding with their less or more massive development while the escarpments rose from the water's edge ten, twenty, or rare;

Stages of Lake Agassiz during the formation of its beaches.

thirty feet.

In this table
on at its mout
end of Lake T
equidistant fro
Emerson, and (

greater than the in the observed because, as will subsidence of tweet to north-

of Lake Traver

more western c examined completween the thi The letters a, part of Lake A

are found to become a correspondent stage the two stages of the control of the correspondent of the correspondent

south end. Sev

The lake shore morthward ase Lake Traverse, a in the third dista

whole ascent thus from slightly less lightly more that ix lower stages

tem to be united of the lake, the relately 30, 40, 60 tourse of these s

bout 55 feet belo he outlet and c etween these sta Between the se

te upper Norc

eaches, the Rive

C.S. Geological Su

On this area the oba is very low. sending part of ghost stages has ower part of this as of less extent n by areas of till nitoba, and from to Shoal Lake.

ll with frequent epth of a few feet ten miles farther nity of Methregor few noticed being e on till that has hese boulders are afterward spread onceal them. No of the delta and of observed sections

EACHES.

parallel with each Lakes Winnipeg to north, which is slowly diminishes ast only slightly west side of Lake termined by conurveys, through a at Lake Traverse id the accompany. lake during the each other and to ave been assumed slope of the beach s, the crests of the een feet above the ive development

, twenty, or rarely

In this table the estimated stages of the lake are noted for comparison on the son at its mouth, where it outflowed by the River Warren at the north through Fargo, and of Lake Traverse, and on four lines of latitude which are nearly Emerson, and auditistant from each other, passing through Fargo, Grand Forks, Gladstone, Emerson, and Gladstone, respectively 75, 150, 224, and 308 miles north f Lake Traverse. Though the fourth of these intervals is somewhat greater than the others, it may still be considered equivalent to them the observed elevations and northward ascent of the lake shores, because, as will appear farther on, the northward rise of the land and subsidence of the lake had their maximum increase from south-southmest to north-northeast, or nearly in that direction. Therefore the more western course of these beaches in the northern part of the area examined compensates approximately for the additional distance

the letters a, b, c, d, represent successive beaches along the northern Successive and of Lake Agassiz, which are merged in a single beach toward its stages of designated by outhend. Several of the beaches thus noted in a preliminary report * letters. are found to become double in some parts of their northward extent; and a correspondence in notation is here preserved by designating mordinate stages by double letters, as aa, bb. There are also added the two stages of the Tintah beaches, which were discovered after the publication of that report.

letween the third and fourth of these groups of observatious.

The lake shore belonging to the highest or Herman stage a has now Northward morthward ascent of about 35 feet in the first 75 miles north from ascent of the Herman shore Lake Traverse, about 60 feet in the second 75 miles, and about 80 feet lines the third distance of 74 miles to the international boundary. Its thole ascent thus in 224 miles is 175 feet, by a slope which increases from slightly less than a half of a foot per mile in its southern third to lightly more than one foot per mile in its northern third. Through ix lower stages represented by separate beaches northward which sem to be united in the single Herman beach along the southern third fthe lake, the northward ascent is gradually diminished to approxiately 30, 40, 60, and 70 feet in the four portions of the observed ourse of these shore lines, amounting thus to 200 feet in about 300 iles. On the international boundary the lowest Herman stage dd is

etween these stages appears not to have exceeded ten feet. Between the series of the Herman beaches and that of the Norcross eaches, the River Warren eroded its channel about fifteen feet; and he upper Norcross shore ascends northward in these successive

bout 55 feet below the Herman stage a, while the probable erosion of

be outlet and consequent lowering of the south end of the lake

^eU.S. Geological Survey, Bulletin No. 39, p. 20,

STAGES OF THE GLACIAL LAKE AGASSIZ, WESTERN SHORE.

			Mouth of Lake Arassiz outflowing by the River Warren, at the north end of Lake Traverse.	On the latitude of Fargo and Wheatland, North Dakota, 75 miles north of Lake Traverse.		On the latitude of Grand Forks and Larimore, North Dakota, 150 miles north of Lake Traverse.		on the international boundary, 24 miles north of Licke Traverse.		On the latitude of tilad stone, Arden and Nee- pawa. Manticka, he miles in take	
	В	EACHES.	Feet above the sea.	Feet above the sea.	North ascent from Lake Traverse.	Feet above the sea.	North ascent from Lake Traverse.	Feet above the sea.	North ascent from Lake Traverse	Fred ishes or the seit.	North greet if from
Stages during outflow southward.	Herman beaches.	\begin{cases} a_0 & \\ a_0 & \\ b_0 & \\ c_0 & \\ d_0 & \\ \end{cases}	1055 1055 1050 1050 1045 1045 1045	1090 1090 1085 1085 1080 1075	35 35 35 35 35 30 30	1150 1145 1135 1132 1125 1117 1115	95 90 85 82 80 72 70	1230 1222 1212 1205 1190 1180 1175	175 167 162 155 145 135 130	1313 1295 1275 1255 1245	
	Norcross beaches. Tintah beaches.	{ a	1030 1025 1015 1000	1055 1050 1035 1017	25 25 20 17	1090 1080 1065 1045	60 55 50 45	1145 1130 1105 1080	115 105 90 80	1215 1185 1150 1120	19
	Campbell beaches.	{ '',	990 985 980	1000 995 988	10 10 8	1015 1010 1000	25 25 20	1045 1035 1022	50 42	1080 1070 1055	1
	McCauley beaches.	$ \text{ville } \begin{cases} a & \dots \\ aa & \dots \\ b & \dots \end{cases} $	970 965 960	977 971 965	7 6 5	987 981 975	17 16 15	1007 998 990	37 33 30	1023	1
$\begin{array}{c} \text{Blanchard} \\ \text{beaches.} \\ \text{beaches.} \\ \text{c.} \\ \text{c.} \\ \text{Hillsboro beach.} \\ \text{Ojata beach.} \\ \text{Ojata beach.} \\ \text{Ojata beach.} \\ \text{Gladstone beach.} \\ \text{Ossowa beach.} \\ \text{Stonewall beach.} \\ \text{Stonewall beach.} \\ \text{Stonewall beach.} \\ \end{array}$		(945)* (935) (925) (915) (882) (860) (840) (822) (810) (795)	950 940 928 918	(5) (5) (3) (3)	960 948 935 923 890 865 845 827	(15) (13) (10) (8) (8) (5) (5) (5)	960 947 935 902 877 857	(22) (20) (20) (17) (17) (15) (12)	986 965 953 920 895 875 855 840	And the State of the State of the State of	

^{**} Figures in parentheses in the first column give approximately the elevations which stages of the lake during its outflow northward would have had at Lake Traverse, if the aber had been low enough to permit the lake to extend south to its former outlet. From estimated elevations the northward ascents of these stages, also in parentheses, are obtained to be directly compared with the northward ascents of the beaches that were found in the lake outflowed southward, showing the changes which were gradually taking place in levels of the beaches of Lake Agassiz during the whole time of its existence.

distances about entire distance

hathird of a f for per mile in slightly reduce is 160 feet. \ \ between the N of the lake leve 25 feet on the l Tintah stage a distances from same distances feet, in total 90 and 28 feet, in about 5, 10, 15 Warren from th end of which th vertical distanc ø Gladstone i attributable to level on account of northward as outhern part of iches per mile from the tin outflow of Lake pertheastward c now a descent Niverville beach sive remained, Tunipeg. The

buth to Lake ?

lout 50 feet to

love the level of

niles from Lake
Winnipeg. The

he lowest McCa

outlet decreases examined north approximately f bout two inche

outhward, and bove the presen SHORE.

Feet above the Sea. alle Feet above North

7 6 5 998 33 1023 99030 1012 975 (30) 3) 960 (25) 980 947 (22) 965.

(8) (8) (5) (5) 935 (20) 953 902 (20) 920 895 877 (17) 857 875 837 (15) 855

> 805 (10) 820

(12)840

770

the elevations which ake Traverse, if the ormer outlet. From the parentheses, are obtain as that were formed wi lually taking place i

distances about 25, 35, 55, and 70 feet, amounting to 185 feet in the entire distance of 308 miles. In the most southern quarter its ascent hathird of a foot per mile, and this gradually increases to nearly one for per mile in the most northern quarter. These rates of ascent are slightly reduced in the second Norcross stage, where the total ascent 160 feet. While the outlet was being eroded probably five feet between the Norcross stages, the combined rise of the land and decline Northward of the lake level were about 10 feet on the international boundary and Norcross, 35 feet on the latitude of Gladstone. The lake shore belonging to the bell and Tintah stage a ascends about 20, 30, 40, and 45 feet in the successive shore lines distances from south to north, amounting in total to 135 feet; in the same distances the Campbell a shore ascends about 10, 15, 30, and 35 feet, in total 90 feet; the McCauleyville a shore ascends about 7, 10, 20, and 28 feet, in total 65 feet; and the McCauleyville b shore ascends shout 5, 10, 15 and 22 feet, in total 52 feet. The erosion of the River Warren from the Norcross a stage to the McCauleyville b stage, at the and of which the southward outflow ceased, was about 70 feet; but the rertical distance between the shore lines of these stages on the latitude of Gladstone is about 200 feet, the difference of 130 feet being atributable to the northward rise of the land and the fall of the lake evel on account of the diminished attraction of the ice-sheet. The rate morthward ascent is reduced to less than an inch per mile along the outhern part of the lowest McCaulevville shore, and to three or four phes per mile along its northern part, the average being two inches. from the time of this lowest beach formed during the southward authow of Lake Agassiz to the time of the first beach formed during its prtheastward outflow, the lake fell only about 15 feet. Thence there now a descent, on the latitude of Gladstone, of about 220 feet to the Niverville beach, below which Lake Agassiz, while its northern barrier fice remained, fell about 45 feet more before it was reduced to Lake

lout 50 feet to 25 feet or only 20 feet in their total northward ascent love the level of the present time along the dista: ce of more than 300 niles from Lake Traverse to the south ends of Lakes Manitoba and Vinnipeg. The whole descent on the latitude of Gladstone, between he lowest McCauleyville beach, where Lake Agassiz ceased to outflow buthward, and the original level of Lake Winnipeg, about 20 feet have the present surface of that lake, is about 280 feet, of which

bout two inches per mile. If these stages of the lake had reached

buth to Lake Traverse, they would probably show a decrease from

Winnipeg. The northward ascent of these shore lines of northeastward Northward utlet decreases only very slightly in the distance of 75 or 80 miles ascent of asmined north of the international boundary, the change being formed during proximately from 20 feet to 15 feet or less, that is, to the rate of Hudson Bay.

the relative h

with only al

secondary bon from Lake Tr.

have been exp

of 140 miles, about 65 feet

averaging nea

scents of th

Minnesota, and ske during i

nearly as on th

of the western

teature of the to east similar

diminishing in

on the intitude

Herman stage

3 feet in abou

serv nearly ha

Herman stages

Vorcross shore

et in about 60 alv three or fe

se stages app north. Th

orthward, in

Wahpeton and Agassiz, the asc

5 miles; at the

he outlet, it is

50 miles north

These observe

nd east shores,

nd surfaces of l

absequent time scent from sou

that greater th

ne north course

of to sixteen in evel which in it

ne foot per mile

probably 25 or 30 feet may be due to the northward rise of the land and diminution of gravitation toward the ice-sheet, while about 250 feet are due to the gradual lowering of Lake Agassiz by its successive outlets to Hudson Bay.

The depth of Lake Agassiz above the present surface of the south Successive The depth of Lake Winnipeg was about 600 feet during its higher Herman Agassiz above end of Lake Winnipeg was about 600 feet during its higher Herman Lake Winnipegs stages, 500 feet at the upper Norcross stage, 440 feet at the upper Norcross stage, Tintah stage, 370 feet at the upper Campbell stage, and 325 feet and 300 feet in the upper and lower McCauleyville stages, being thus reduced to half of its earlier depth before it ceased to flow to the south During the lower stages of outflow to the northeast, the depth of Lak Agassiz above Lake Winnipeg decreased to 285 feet at the appearance Blanchard stage, about 240 feet at the time of the Hillsboro beach, 216 feet in the Emerado stage, and successively about 185, 165, 145, 136 110, and 65 feet in the Ojata, Gladstone, Burnside, Ossowa, Stonewall and Niverville stages. By nearly proportionate gradations the area of Lake Agassiz was diminished through these successive stages, having when the outflow to Hudson Bay began probably about half of it maximum extent attained during the formation of the Herman beach.

Proportionate decrease in

> Exploration of the beaches formed on the east side of Lake Agasij has been mostly limited to Minnesota, because the eastern part of ti., lake area in Manitoba is covered by forest and is almost wholly without settlements or roads, so that for the present a survey of the shore lines there is impracticable. For the same reasons the upper shores; Minnesota have not been exactly traced east of Maple Lake, which twenty miles east-southeast of Crookston. Within the prairie are across which the highest eastern shore has been surveyed and is elevation determined by levelling, its northward ascent is about III feet in 140 miles, from 1,055 feet above sea at Lake Traverse to 1.17 feet at the north side of Maple Lake. As on the western shore of Lak Agassiz, the rate of ascent gradually increases from south to north ranging from six inches to one foot per mile in its southern portioning about 75 miles, and from one foot to sixteen inches per mile farther north. Before the lake in Minnesota had fallen below its higher eastern beach in the south half of its explored extent, the rise of the land and diminished attraction of the waning ice-sheet had caused slightly lower parallel beach, three fourths of a mile to one and a hi miles distant, to be formed through the northern third of Clay Country and this secondary beach, sometimes double or treble, is observables several places along the next 30 miles northward. At the northwa side of Maple Lake definite beach ridges belonging to the Herma stages of Lake Agassiz lie successively about 8, 15, 30, and 45 fe scent of approx below its highest beach. Yet all these shore lines were formed while

Comparison with the eastern shore nes in Minnesota

d rise of the land , while about 25a by its successive

rfuce of the south s higher Herman feet at the upper and 325 feet and tages, being thus flow to the south. the depth of Lake feet at the upper illsboro beach, 210 185, 165, 145, 130 Issowa, Stonewal dations the area of sive stages, having about half of is e Herman beaches le of Lake Agassia eastern part of the jost wholly withou y of the shore lines e upper shores i le Lake, which li n the prairie an surveyed and i scent is about 11 e Traverse to 1.17 stern shore of Lak

outhern portion in es per mile farthe below its higher ent, the rise of the -sheet had caused le to one and a hal ird of Clay County ole, is observable

m south to north

At the northwo ng to the Herma 15, 30, and 45 fee were formed while

the relative heights of the land and the lake continued stationary or with only slight change, not sufficient for the formation of any secondary beach ridge, along a distance of some 75 miles northward from Lake Traverse and Herman. The Norcross beaches in Minnesota have been explored and their height measured through the same extent of 140 miles, in which the upper Norcross beach ascends northward about 65 feet by a slope that increases slightly from south to north, averaging nearly six inches per mile. In like manner the northward ascents of the Tintah, Campbell, and McCauleyville beaches in Minnesota, and of the lower beaches formed on this east side of the ske during its outflow to the northeast, show a gradual decrease nearly as on the west in North Dakota and Manitoba. But comparison of the western and eastern shores reveals another very interesting The eastern feature of the levels of this glacial lake, namely, an ascent from west higher than the western shore beast similar to that from south to north, but of less amount and lines. aminishing in a similar ratio between the successive stages of the lake. on the latitude of Larimore and Grand Forks the ascent of the highest Herman stage of Lake Agassiz above a line now level is approximately get in about 70 miles from west to east, the rate per mile being gery nearly half as much as from south to north; and in the later Merman stages it is diminished to about 30, 25, and 20 feet. On the Yorcross shore lines this ascent toward the east is approximately 10 bet in about 60 miles, and it is reduced in the McCauleyville stages to aly three or four feet in about 50 miles; yet it continues through all liese stages approximately half as much per mile as the ascent toward he north. The rate of ascent eastward also increases, like that orthward, in proceeding from south to north. At the latitude of Wahpeton and Breckenridge, 35 miles north from the mouth of Lake tenssiz, the ascent of its highest stage is 10 feet from west to east in 5 miles; at the latitude of Fargo and Moorhead, 75 miles north from be outlet, it is 15 feet in 50 miles; and at the latitude of Grand Forks, nmles north from the outlet, it is 33 feet in 70 miles. These observations, with those of the northward ascent of the west

ad east shores, indicate that the changes in the relations of the land ad surfaces of level during the existence of Lake Agassiz and through absequent time have given to the former levels of this glacial lake an seent from south-southwest to north-northeast, its rate being somethat greater than that noted in following the shores in their nearly me north course. The maximum rates of northward ascent of about Maximum ne foot per mile observed in North Dakota and Manitoba, and of one ascent of the to to sixteen inches per mile in Minnesota, therefore belong to a lake Agassiz toward wel which in its northern portion differs from the present level by an northeast. gent of approximately one and a half feet per mile toward the north-

northeast. Similar north-northeastward ascent continues through the successive lower stages of the lake, in which its amount north of the international boundary is reduced to about four inches per mile at the lowest stage of southward outflow; and probably it was not more than two inches per mile when the course of the Nelson River was uncovered by the receding ice-sheet.

Changes in relative elevations nearly or quite completed during the existence of Lake Agassiz.

Nearly the entire amount of the changes in the levels of the beaches of Lake Agassiz was evidently contemporaneous with the existence of this lake, taking place gradually, but apparently progressing comparatively fast between the stages marked by the formation of definite beaches, which doubtless belong to times when these changes advanced very slowly or were interrupted by intervals of repose. Great as were these modifications of the geoid surface of level, causing a differential uplift of the highest western shore of the lake in Manitoba to the extent of 175 feet at the international boundary, 265 feet at the latitude of Gladstone, and about 400 feet at latitude 51°52' on the east side of Duck Mountain, 200 miles north of the international boundary, in the relation of the land to the water level, as compared with the vicinity of Lake Traverse, they were yet almost or perhaps quite completel before the ice-sheet was so far withdrawn that it was no longer a barrier to prevent free drainage from the basin of the Red River and Lake Winnipeg. During the subsequent postglacial epoch, to the present time, only very slight changes, or possibly none, have taken place in the relative elevations of the part of this area where the beaches of Lake Agassiz have been traced with levelling in Minnesota North Dakota, and Manitoba; and if there have been such small pos glacial changes, they were merely a continuation of the good more ments which accompanied the recession of the ice-sheet and an recorded by the successive shore lines of this lake.

Further important evidence is supplied by this survey of the beach Relation to the of Lake Agassiz in respect to the limitation in time and in area of the upheaval of the Cordillera region, comprising the Rocky and Sierz region and of the great plains. Nevada Mountains, and of the great plains which stretch from the Rocky Mountains east to the border of the Red River Valley. To somewhat higher elevation of the eastern than of the western sheet of the last glacial epoch and since then has not participated; this extensive uplift, which increases from east to west across the

this extensive uplift, which increases from east to west across the plains. Prof. Joseph Le Conte has shown that the Sierra Neval range and other portions of the Cordillera region obtained a graph part of their elevation within the glacial period; * and Prof.

c Chamber
c Mississip
c interglac
n plains be
received
comparise
s western u

ice-sheet.
Consider leaches, rarea example the character of the character of a great character of a great character of a great character of a great character of the character o

Sath annual to logical an l goal Survey sailar oscille this ascrebe

ther than

American Journal of Science, III, vol. xix, pp. 176-190, March, 1880; and vol. xxxii, ff-181, Sept., 1886, Compare also J. S. Diller's observations on the time of the upliffing faulting which produced the Sierra Nevada, Eighth annual report of the U. S. Geden Survey, pp. 428-432.

tions as erribed mate and Time emphischen (le

ontinues through the amount north of the ches per mile at the it was not more than on River was uncor.

BA.

levels of the beaches with the existence of ly progressing comformation of definite ese changes advanced epose. Great as were causing a differential e in Manitoba to the 265 feet at the latitule 52' on the east side of ional boundary, in the ared with the vicinity rhaps quite completed at it was no longer a of the Red River and tglacial epoch, to the sibly none, have taken f this area where the levelling in Minnesota e been such small post ion of the geoid move the ice-sheet and an s survey of the beach

time and in area of the the Rocky and Sierr vhich stretch from the ed River Valley. T n of the western short he recession of the in has not participated ast to west across at the Sierra Neval egion obtained a gra period; * and Prof

larch, 1880; and vol. xxxii. the time of the uplifting report of the U. S. Geoler

chamberlin and Salisbury conclude that the upper portion of the Mississippi basin was raised 800 or 1000 feet during the principal interclacial epoch. * Simultaneously with these movements, the plains between Lake Agassiz and the Rocky Mountains doubtless received a considerable part of their slope of ascent westward; but comparison of the opposite shores of Lake Agassiz indicates that the western uplift was probably completed before the departure of the last Consideration of the character of the changes in the levels of the

heaches, resulting in a greater ascent upon the northern part of the area examined than farther south, and gradually approximating through the successive stages of the lake to parallelism with the present good surface of level, led me in my earlier studies to attribute these changes almost wholly to gravitation of the water of the lake exard the ice-sheet. The cause of the present relations of the old Gravitation of hore lines seemed to be discovered in the explanation that at first this the ico-sheet, attraction had a large effect upon the lake level because of the nearness the changes in the great depth of ice on the east in northern Minnesota and on the levels of the of a great depth of ice on the east in northern Minnesota and on the beaches. with in British America, but that afterward it was gradually iminished to a comparatively small influence when the southern prion of the ice-sheet had been melted and the attracting force proceeded from the region far north between Lake Winnipeg and Hudson Bay, † Under this view the earth's crust was believed to be origid that it was not depressed by the vast weight of the ice nor gised when relieved of that weight, and the changes were believed to posist chiefly in the differential subsidence of the lake level, not in the derential elevation of the land basin, The general uniformity of best changes in their direction and extent, and their probable cometion during the departure of the ice-sheet seemed to accord with lishypothesis. The exact comparison of the shore lines observed on oth the east and west sides of the lake, extending for its upper stages 10 miles from south to north in Minnesota and more than 300 miles om south to north in North Dakota and Manitoba, shows no condetable irregularity in the rates of northward and eastward ascent, latis, of north-northeastward ascent of the former lake levels, which as seem to be attributable to gravitation toward the waning ice-sheet, ther than to a progressive elevation of the land, for that would be

Sixth annual report of the U.S. Geological Survey, p. 314. irological and Natural History Survey of Minnesota, Eleventh annual report, p. 152; U. S. elegical Survey, Bulletin No. 39, p. 18.

smilar oscillations in the relative heights of sea and land, associated with glaciation, have whas ascribed to lice attraction by Adhemar, in Révolutions de la Mer, 1840; by Croll, in mate and Time, 1875; and by Penck, in Schwankungen des Meeresspiegels, Jahrbuch der crophischen Gerellschaft zu Munchen, bd. vii, 1882.

he as great in

expected to present noteworthy irregularities upon so large an area. It is probable, however, that close scrutiny of the shore lines will disclose small divergencies, within limits of a few feet, from the uniformity of slopes which they should have for agreement with this explanation: and it is to be noticed that the highest shores in the vicinity of Treherne. Brandon, and Neepawa have more nearly a northward than north-northeastward ascent, also that a slightly disproportionate increase in the ascent of the highest Minnesota shore line in the next ten or fifteen miles north of the Buffalo River was ascribed to the proximity of a portion of the ice-sheet on the east, where it was form. ing the Fergus Falls and Leaf Hills moraines. Though it now appears true that the greater part of these changes of level are due to the differential rise of the land, the gravitation of the lake toward the ice sheet certainly operated in conjunction with that cause, contributing to the full extent of its competency in producing the results observed.

Mr. R. S. Woodward, of the United States Geological Survey, has nathematical investigation of worked out the mathematical problem of determining the effect of any ice attraction added mass, as an ice-sheet. Upon the coult is a country of the country levels of the sea and of lakes.* Assuming an ice-sheet with a radial extent of 38°, or about 2,600 miles, and a central depth of 10,000 feet from which the depth decreases at first slowly and then more rapidly to its border, he finds that the average slope within one degree of the border of the ice would be about five inches per mile, or less than on third of the north-northeastward ascent of the highest shore lines. Lake Aga-siz in the north part of the area where they have bee explored. Comparing the premises in this problem with the probable conditions affecting this glacial lake, it seems sure that the North American ice-sheet in its maximum extent during the last glaciepoch covered not more than one fourth so great area, its extent bein equivalent to a spherical circle with radius of 1,000 miles, or at the most 1,300 miles; but, on the other hand, it is probable that the maximum depth of this ice-sheet somewhat exceeded 10,000 feet, and that the area of this great depth was a belt extending eastward from a fe hundred miles north or northeast of the south part of Lake Agassiz a distance of about 1,000 miles east-northeast, lying thus much near than in the assumed case of Mr. Woodward's investigation. The small area and less total mass of the ice-sheet attracting Lake Agassiz m have been offset by the nearer position of a large part of its mass that in the assumption of the problem, so that possibly its influence mig

the present t gravitation of highest shore at the most n ttains a max his belongs t feet per mile. evels of the be emaining thre outh to north. fthe earth's c Among the c he land on wh he earth's crus arming and e: merficial porti emperature of ells situated r oring the tim e temperature eezing point, S av have affect einfluence of geotherms, w e land surfac mperature of at Lake Tr tesian waters terior. In lil perficial portio 32°, at which elting the ice,

Geological and Natu C. A. Schott in Smit s of the United ha for 1892, p. 318

the temperatu ter permeatin

reed 15° from

in of Lake A

ttson County,

samount at W

^{*} U.S. Geological Survey, Sixth annual report, pp. 291-300; and Bulletin No. 48, "9 Form and Position of the Sea Level." Compare also Prof. Edward Hull's computations the Effect of Continental Lands in altering the Level of the adjoining Oceans," Ge Magazine, Dec. III, vol. v, pp. 113-115, March, 1888,

he as great in producing an ascent of the lake level above the level of arge an area. It the present time; but, if this mathematical investigation is reliable. ines will disclose emvitation of the lake toward its ice-barrier could not give to its the uniformity of sighest shore a northward ascent of more than a few inches per mile. this explanation: the most not so much as half a foot, whereas its observed ascent the vicinity of mains a maximum rate of one foot to sixteen inches per mile, and a northward than his belongs to a north-northeastward ascent of fully one and a half disproportionate bet per mile. A quarter part, or perhaps less, of the changes in the e line in the next arels of the beaches is therefore referable to ice attraction; while the is ascribed to the emaining three quarters, amounting to about 130 to 300 feet, from vhere it was form. ath to north, in western Manitoba, belongs to differential elevation gh it now appears fthe earth's crust. el are due to the ake toward the ien ise, contributing to

Among the conditions producing changes in the height and slopes of Effect of he land on which Lake Agassiz lay are the cooling and contraction of temperature of he earth's crust by the ice-sheet and glacial waters, and the subsequent the earth's rarming and expansion owing to the amelioration of the climate. The the ice-sheet. sperificial portion of the earth's crust in the Red River Valley has a apperature of 47° to 42° Fahrenheit, as shown by the water of artesian alls situated respectively at Ada and Donaldson, Minnesota,* But ging the time when this district was covered by the ice-sheet, etemperature of the underlying land surface was reduced to the ezing point, 32° Fahrenheit, and a similar lowering of temperature whave affected the crust to a considerable depth, largely through sinfluence of percolating water, causing a slight depression of the geotherms, with consequent contraction of the rocks and lowering of and surface. By comparison with the present mean annual gerature of the Red River Valley, ranging approximately from at Lake Traverse to 33° at Winnipeg,† it is evident that the reian waters before noted receive part of their heat from the earth's perior. In like manner probably the interior heat kept the perficial portion of the earth's crust beneath the ice-sheet as warm 32°, at which temperature the earth's heat would be continually ding the ice, though doubtless at a very slow rate. The differences he temperatures of the earth's crust, due to the ice-sheet and to her permeating downward from it, would not therefore probably ged 15° from that of the present time in the southern part of the in of Lake Agassiz, and would decrease to 10° at Donaldson in tton County, the most northwestern in Minnesota, and to even a samount at Winnipeg. The extent to which these slight changes

its influence mig id Bulletin No. 45, " I Hull's computations. joining Oceans," tie

esults observed.

ogical Survey, has

ng the effect of any

face, to disturb the

sheet with a radial

lepth of 10,000 feet

d then more rapid

in one degree of the

ile, or less than on

ghest shore lines

ere they have been

m with the probable

ure that the North

ing the last glad

rea, its extent bea

miles, or at the m.

e that the maxima

feet, and that the

astward from a le

t of Lake Agassiz

ig thus much near

gation. The sma

g Lake Agassiz m

part of its mass h

belogical and Natural History Survey of Minnesota, Eleventh annual report, pp. 147, 148. C.A. Schott in Smithsonian Contributions to Knowledge, vol. xxi, 1876: Atlas of the Tenth s of the United States; Report of the Department of Agriculture and Statistics of ha for 1882, p. 318,

in the crustal temperatures would depress the land while it was ice covered and raise it when the ice was withdrawn depends on the ratios of contraction and expansion of the underlying rocks. These ratios have been experimentally determined in the case of various building stones, and computations therefrom indicate that only a very small amount of subsidence and elevation of the land could be caused in this way.* The total elevation so produced was probably not more than fifty feet in the southern part of the Red River Valley and not more than thirty feet at Winnipeg, and its slight differential effect would be in the opposite direction to that which has given to the beachs of Lake Agassiz their northward ascent. This element in the causatom of the changes of elevation appears to be comparatively insignificant in itself, and its small component in the oscillation of the shore lind would be opposed to that for which we are seeking an explanation

Probable dependence of the northward ascent of the beaches upon the departure of the icesheet.

It seems to be very clearly indicated, however, by the gradu diminution in the northward ascent of the beaches until the lowest an latest have nearly the level of the present time, that these progressis changes of elevation were directly dependent upon the departure of the ice-sheet, with which great geologic event they were contemporaneous As already noted, these changes were so directly proportionate wi the glacial recession that the northward ascents of the succession beaches were at first referred to the diminishing gravitation of the la toward the ice-sheet; but, apart from the inadequacy of this can determined by Mr. Woodward's investigations, the great extent of a highest beach and its relation to terminal moraines marking stages the glacial recession sufficiently demonstrate that other causes com buted even more than ice attraction to produce the changes observe in the levels of the beaches. In the discussion of this subject to presented in the monograph of Lake Agassiz for the United Sta Geological Survey, there remain to be considered, as probable caus first, the relationship between the earth's crust and its interior whi may have permitted a sinking of the crust beneath the vast weight the ice-sheet and a re-elevation when that weight was removed a second, oscillations which may have occurred without dependence the glaciation. For the discrimination of these movements, it will very instructive to notice the changes of elevation that have going forward at the same time in other parts of the North American and European glaciated regions, and also in various areas which never thus ice-laden. If Lake Agassiz is found to be an insta where nearly all these changes are apparently referable to glacial there will be no lack of opportunity for comparing it with

regions where dent crustal n

The followi how in consid nd in a few verywhere an rear, is found restward it us reams, contai e used satisfac commonly co iste: ns, it is 1 ten somewhat be injurious But wooden v this region, kaline; and v lightly, the wa ren by cattle, a age. If bricks nd the water in om, it is entire arly all uses, e id for steam-b m it in evapo Artesian or fl Winnipeg an om layers of sa Winnipeg. Al s of Winnipeg attan, the city to the bed-rock ter from lavers the west part o ly to five or ter od quality for c

tter in solution
These Quaternary cl
st of Glaciation," for

[•]T. C. Chamberlin in Sixth annual report, U.S. Geol. Survey, p. 302, and in paper really the Philosophical Society, Washington, March 13, 1886; G. K. Gilbert, in Am. Jour. St. vol. xxxi, p. 297, April, 1896.

while it was ice. depends on the ing rocks. These e case of various e that only a very nd could be caused

probably not more ver Valley and not t differential effect given to the beaches ent in the causaum tively insignifican n of the shore line an explanation, er, by the gradual

until the lowest and at these progressive the departure of the re contemporaneou proportionate wit its of the successiv ravitation of the las quacy of this caus e great extent of the es marking stages t other causes conn the changes observe of this subject, to or the United State d, as probable caus nd its interior whi

th the vast weight t was removed, a ithout dependence movements, it will tion that have le the North Ameri ous areas which id to be an insta eferable to glaciat

paring it with

302, and in paper read

lbert, in Am. Jour. Se

regions where the effects due to glaciation are combined with independent crustal movements, *

RECORDS OF WELLS.

The following notes of common wells in various parts of Manitoba how in considerable detail the character and order of the drift deposits, nd in a few instances of the underlying rock formations. Nearly verywhere an ample supply of good water, permanent throughout the gar, is found at a moderate depth. In the Red River Valley and setward it usually is hard water, as is also the water of springs and reams, containing so much dissolved carbonate of lime that it cannot e used satisfactorily for washing with soap. For this use rain water commonly collected from the roofs. When this is stored in large stems, it is more desirable also for drinking and cooking than the ten somewhat alkaline well water, which, however, is seldom found be injurious to health.

But wooden well-curbing, commonly pine, which has been often used wells often this region, soon contaminates the water, especially if it is notably contaminates the water is not account to valine; and when such wells are left stagnant or only drawn from curbing. ightly, the water becomes too foul in smell and taste to be drank, ten by cattle, and it may be the cause of sickness before reaching this age. If bricks, stone, or iron or cement pipe are used for lining wells. d the water in them is frequently renewed by being largely drawn om, it is entirely wholesome and palatable, and is well adapted for arly all uses, excepting for washing with soap, as before mentioned, d for steam-boilers, in which the large amount of scale deposited om it in evaporation is objectionable.

Artesian or flowing wells are obtained near the Red River, as in Artesian wells. Winnipeg and southward, where water often rises to the surface on layers of sand and gravel in the drift.

Winnipeg. About forty wells have been bored by the city authorisof Winnipeg for supplying water for domestic use. Mr. H. N. attan, the city engineer, states that about a dozen of these wells go to the bed-rock, which is limestone, while the others derive their ter from layers of quicksand in or beneath the till. Several of them the west part of the city are artesian, but eastward the water rises y to five or ten feet below the surface. The water is considered of ed quality for drinking and cooking, but it contains much mineral tter in solution, chiefly the sulphates of lime and magnesia.

These Quaternary changes of level have been partly considered in a paper on the "Probable sof Glaciation," forming an appendix of Prof. G. F. Wright's Ice Age in North America,

Alluvial and drift deposits.

Alluvial stratified clay extends to a depth that varies from three to ten feet or more. This is underlain by the glacial till or boulder-clay, which encloses thin veins and layers of fine gravel and sand, and frequently is underlain by sand and gravel, but in many places extends to the limestone. The upper part of the till here shows an imperfect stratification, due to its deposition in Lake Agassiz, and contains a less proportion of boulders and gravel than its lower part, which is very hard, and is therefore commonly denominated "hard pan." The depth to the limestone varies from thirty to sixty feet in the west part of the city, and increases to about seventy-five feet eastward.

of the till.

Underlying limestone. One of these wells, bored in the west edge of the city, close north of the Assiniboine and one and a half miles west of the Osborne street bridge, went 32 feet in stratified clay and till, and then 100 feet in limestone, mostly of light buff or cream color, obtaining water of god quality at 132 feet, which rose to five feet below the surface. The bed-rock is nearly like that which outcrops at Lower Fort Garry and East Selkirk.

General section of superficial deposits at Winnipeg.

A general section of the superficial deposits at Winnipeg is notedly J. Hoyes Panton as follows, from information supplied by Mr. Piper known as having an extensive experience in well-boring throughest the city.

"1. Surface mould, one to four feet, dark color, and exceeding fertile.

"2. 'Yellow gumbo,' two to three feet, a very sticky form of yellow ish clay, which usually holds considerable water.

"3. Dark gray clay, thirty to fifty feet thick, with boulders scattered throughout; some of them four feet in diameter, and chiefly gneissed and no doubt derived from Laurentian rocks.

"4. Light-colored clay, one to three feet, containing many smatter tones.

"5. Hard pan, two to ten feet, a very solid and compact form; clay.

"6. Sand, gravel, and boulders, five to twenty-five feet.

"7. Angular fragments, one to three feet, usually limestone a largely derived from the solid rock which lies immediately below it.

"This loose material is far from being uniform, and varies so may in its arrangements that scarcely any two borings show the same of tribution. Sometimes there is little or no hard pan, while in other parts it is several feet thick. However, as a usual thing, these so forms of strata are passed through in boring, and varying in thicker to the number of feet already mentioned."

Saint Bon Winnipeg, o

Winnipeg, of on the Exhi 36 feet, its lebedrock at white, penet Viverville.

and till; wa this village bed-rock; bu of about 100 Four miles

this same T.

ville beach, p shale, 30 feet, In the S. W Freesen has a into the shale wells in this 1

Dominion Ci 170 feet deep, depth of 120 teebly, not use The commo

107 feet.

water which see
The Roseau
the short stream
City, taking wagineers above

Emerson. Wallavial clay, and it is very life with the west Lynne.

et deep; dug of ewer, apparent nough to supplimost wholly offinary wells if eping in suffice Artesian wells

nthe French 1 welve miles not

^{*}Report of the Department of Agriculture and Statistics, Manitoba, for 1882, p. 176.

ries from three to Il or boulder-clay, and sand, and free places extends to ows an imperfect and contains a less part, which is very pan." The depth the west part of the

rd.

vity, close north of
the Osborne stree,
d then 100 feet in
ning water of god
7 the surface. The
wer Fort Garry and

innipeg is noted by plied by Mr. Piper l-boring throughou

or, and exceeding icky form of yellow

th boulders scattere nd chiefly gnessed

taining many sm

nd compact form

ve feet.
nally limestone, as
nedintely below it,
, and varies so me:
i show the same if
pan, while in oth
al thing, these set
yarying in thicks

a, for 1882, p 176.

Saint Boniface. Wells in St. Boniface are nearly the same as in Winnipeg, on the opposite side of the river. The deepest learned of is on the Exhibition Ground, 156 feet deep, being stratified clay and till, 35 feet, its lowest 10 feet very hard and compact; sand, 44 feet, to the belrock at 80 feet; then limestone, of light cream color or nearly white, penetrated 76 feet and extending below.

Micretille. Thomas W. Craven, hotel; well, 65 feet deep, in alluvium and till; water rises to fifteen feet below the surface. Other wells in this village have nearly the same depth or less, none coming to the belock; but it was reached by a well a third of a mile east at a depth of about 100 feet.

Four miles south-southeast of Niverville, in the N. E. 4 of sec. 5 in his same T. 7, R. 4 E., Cornelius Freesen's well, situated on the Niverville beach, passed through alluvium and glacial drift, 65 feet, and hale, 30 feet, obtaining an ample artesian flow of excellent water.

In the S. W. ‡ of this section, a half mile from the foregoing, Adam Flowing wells freesen has a similar flowing well, 107 feet deep, which went 37 feet nonite Reserve into the shale. This is said to be the deepest of about twenty flowing Red River. wells in this Mennonite Reserve, their range of depth being from 40 to 107 feet.

Dominion City. James Spence, Victoria Flour Mills: flowing well, 150 feet deep, in alluvial clay and till, the latter very hard below the depth of 120 feet; bed-rock not reached; water brackish, flowing nebly, not used.

The common wells of this visuage, 12 to 16 feet deep, have good mater which seeps from the alluvial clay.

The Roseau River has much softer water than the wells and most of Soft water of the short streams of this region, so that the railway tank at Dominion City taking water from the Roseau, is preferred by the locomotive engineers above any other source of water on this branch line.

Emerson. Wells in Emerson range from 10 to 25 feet in depth, in slavial clay, and obtain water tolerably good for drinking and cooking, but it is very hard and unsuited for laundry use.

West Lynne. Hudson Bay Company's steam flouring mill: well, 108 fet deep; dug 68 feet in alluvial and lacustrine clay, and bored 40 feet lover, apparently in the same deposit. The only water found, not nough to supply the engine, is that which seeps from the clay, coming flost wholly within the first twenty feet below the surface. The clinary wells in this village, 14 to 18 feet deep, obtain good water seping in sufficient amount for domestic use.

Artesian wells near Letellier and on the Low farm. An artesian well Brackish the French Reserve at the center of T. 2, R. 1 E., near Letellier, artesian wells welve miles northwest from Emerson and West Lynne, is 250 feet Red River.

deep, not reaching the bed-rock. It supplies brackish water, which is drank by cattle. Another artesian well of similar depth is on the $L_{\rm ow}$ farm, about twelve miles west of Morris, the water of which is strongly saline.

West Selkirk. The well at the Lisgar House, 100 feet deep, reached the bed-rock, which is limestone, at 65 feet,

Stonewall. J. B. Rutherford's flouring mill: well, 82 feet deep, ea. sisting of beach gravel and sand, 10 feet; till. 2 feet; and limestone. including red shaly beds, 70 feet, to the bottom, where the drill fee one foot and water rose immediately to 22 feet below the surface Several other wells in Stonewall have had a similar experience, obtain ing water which rises from hollows in the limestone.

T. 15 R. 2 E. William Andrew, S. E. 1 of sec. 7: well, 94 feet deep; till at the surface and to a depth of 11 feet; and limestone, 83 feet, mostly hard and of light buff color, but enclosing some 25 feet of ted. dish shaly beds between the depths of 45 and 70 feet. There are several such wells in the same vicinity.

Between Pleasant Home and Gimli. Mr. Andrew states that, about twenty-five miles northeast from the last, a well between Pleasant Home and Gimli has been sunk 126 feet, wholly in the glacial drift not reaching the bed-rock.

Rosser. The railway well at Rosser is 29 feet deep, in till, which forms the surface there and east to Little Stony Mountain; water rises fifteen feet from a sandy layer at the bottom.

T. 11, R. 1 E. Robert D. Bathgate, sec. 27: well, 60 feet deep; till 24 feet, from which alkaline water seeps; and light buff, hard limes stone, 36 feet, and continuing lower; water of good quality rises from the bottom to 20 feet below the surface. Other wells in this vicinity mostly get good water in veins or thin layers of sand and gravel con tained in the till.

St. Francois Xavier. On Mr. Nanton's ranch, about ten miles west of Headingly and a quarter of a mile south of the Assiniboine, a well 114 feet deep passed through alluvial clay, 14 feet; till, 34 feet: line stone of light cream color, 47 feet; and reddish limestone. 19 feet Brackish water rises from the bottom to 14 feet below the surface.

Meadow Lea, sec. 30, T. 13, R. 2. Wells in this vicinity range from 20 to 95 feet in depth, and are wholly in till, not reaching the bed-reek

T. 13, R. 6. Charles Cuthbert, sec. 21, ten miles north-northeas from Portage la Prairie: well, 16 feet deep; soil and loamy silt to water in quicksand and fine gravel. The surface here is only a for feet above the high water level of Lake Manitoba.

Portage la Prairie. The common wells are 12 to 16 feet deep, being black soil, 2 to 4 feet; then yellowish gray loamy silt, the alluving nostly 15 to 25 i

of the Assin trees, are oc The deepest way tank, w. large supply

T. 12, R.

close west of depth of 158 blue till, 76 f but containin undoubtedly of this towns feet in diame till very hard much in its h softer than w about an inch which was dry struck a harde for the drill, k becoming stuc bettom within of the well th manent level a this level in dr

A quarter of imilar well as to rock, but it o 864 feet, approx secordingly abo Gladstone. V ilt. Water abi

the surface, nea

it is not suitab

effect, by horse

Arden. In th ection being til om 5 to 15 fee Neepawa. Jo n the town; soi eet; and till, da

oulders, 46 fee

water, which is of the Low which is strongly

eet deep, reached

82 feet deep, eec. t; and limestoke, here the drill feelow the surface, experience, obtain

well, 94 feet deep; imestone, 83 feet, me 25 feet of red. feet. There are

states that, along between Pleasant the glacial drift,

leep, in till, which intain; water rises

60 feet deep: ti., ht buff, hard limequality rises from ells in this vicinity nd and gravel con-

out ten miles west
Assiniboine, a well
till, 34 feet: lims
limestone, 19 feet
w the surface,
licinity range from

ching the bed-rock es north-northest and loamy silt.to here is only a fer

16 feet deep, being silt, the alluving

of the Assiniboine, in which fragments of driftwood, as small limbs of trees, are occasionally found; to water in quicksand and fine gravel. The deepest well here is that of the Manitoba and Northwestern Railway tank, which reaches 30 feet, to till at the bottom, obtaining a very large supply of water.

T. 12, R. 8. Kenneth McKenzie, jr., in the north edge of sec. 2, elese west of Rat Creek: well, dug 86 and bored 72 feet, to a total depth of 158 feet: soil, 2 feet; sand, 4 to 5 feet; yellow till, 4 feet; bine till, 76 feet, easy to excavate, with scanty intermixture of gravel, but containing occasional stones up to one foot or more in diameter, undoubtedly true till, for the surface generally through the south part of this township has plentiful embedded boulders up to two or three feet in diameter; below was "hard pan," a more indurated deposit of fill very hard to dig or pick, bored or drilled 72 feet, and found to vary much in its hardness through this depth, some portions being much ofter than where the boring began. A seam of sand and fine gravel, alout an inch thick, was noticed between the upper part of the till, which was dry, and the harder lower portion. At the bottom the drill grack a harder layer, which was called rock. It was probably shale, for the drill, being dropped a few times upon it, seemed in danger of becoming stuck so that it could not be removed. Water rose from the bottom within the first day to a depth of 20 or 30 feet in the portion of the well that was dug; and within a few days it reached its permanent level about 20 feet below the surface. It does not sink below this level in dry seasons, but in wet seasons iterises to seven feet below the surface, near the bottom of the sand. It is somewhat salty, so that itis not suitable for house use; but it is drank freely, and with no ill effect, by horses and cattle during the entire winter.

A quarter of a mile south of this, Mr. McKenzie's father has a smilar well as to its depth and succession of deposits passed through torock, but it obtains a less ample supply of water. Both wells are \$4 feet, approximately, above the sea; and the top of the bed-rock is scorlingly about 706 feet above the sea level.

Gludstone. Wells vary from 10 to 15 feet in depth, in sandy fine it. Water abundant and of excellent quality.

Arden. In the vicinity of Arden wells are 10 to 50 feet deep, the setion being till, excepting where this is overlain by beach deposits ion 5 to 15 feet thick.

Nepawa. John A. Davidson & Co., store: well, 60 feet, the deepest athe town; soil, 2 feet; gravel and sand of the Assiniboine delta, 12 let; and till, dark bluish, with the usual proportion of gravel and oulders, 46 feet, and extending below; water good. Other wells, notly 15 to 25 feet deep, reach till at nearly the same depth.

T. 13, R. 16. The deepest wells in this township go 50 to 70 feet, wholly in till; but commonly a sufficient unply of water is found within 30 feet or less.

Carborry. Wells 10 to 20 feet deep in . , the Assiniboine delta plenty of good water.

Chater. At the elevator, 42 feet, and at the hotel, 31 feet, wholly in till, yellowish above and dark bluish below; water rose several feet.

Brandon. Wells 10 to 30 feet deep, in delta gravel, underlain by till; good water.

Carman. Depths 10 to 15 feet, in alluvial clay with sandy layers; good water. Two miles south of Carman, James Stewart's and George E. Laidlaw's wells are respectively about 100 and 120 feet deep probably passing through the alluvial and lacustrine clays and glacial drift, to underlying Cretaceous shales. The water of the deeper of these is too brackish for house use, but is drank by cattle.

Treherne. In the vicinity of Treherne wells vary from 15 to 50 feel in depth, the section being beach and delta deposits of stratified grave and sand; excellent water.

Holland. Wells at Holland are 10 to 20 feet deep, in till to shale, which is reached at about 10 feet; water good, generally better from the shale than from the drift. Shale is not encountered by well farther north, on the Assiniboine delta. In the adjoining Tiger Hils on the south, the depth to shale varies commonly from 2 or 3 to 19 or 15 feet.

Cypress River and Glenboro. Depths 10 to 17 feet, in fine silt, the delta of the Assiniboine; water good, issuing from quicksand.

T. S. R. 18. Rounthwaite post-office, sec. 14: well, 20 feet deep, soil, 2 feet; yellowish gray till, 13 feet; harder blue till, 5 feet and lower; water seeps, plentiful and good.

T. 7, R. 17. Williamson, Dignum & Co., farmhouse in sec. 3: we, dug 30 feet and bored 32 feet more; seen while the boring was in progress at depth of 62 feet; all till, mostly yellowish, to that depth. This is half a mile north of the northern base of the Tiger Hills, a an elevation of about 1,350 feet above the sea.

Lang's Valley. Langvale post-office, at James Lang's house, see 1 T. 6, R. 18: well, 18 feet deep: all gravel and sand, with quicks at the bottom. This is on the bed of the channel of outflow to the Pembina from the glacial lake in the Souris basin.

Plum Creek. Wells in this village, at the junction of Plum Cred with the Souris, are 10 to 30 feet deep, in till, not reaching bed-red but outcrops of the Fort Pierre shale occur on the Souris near by.

Gretna. Common wells, 10 to 20 feet deep, in alluvial and lacustria

clay, obtain been made h finding a sup River.

InAV.

Rheinland.

T. 2, R. yellowish tilt to gravel with between the foot of the I that this terr glacial drift.

Morden an frequently al Thornhill.

deep, their m seeps. The t bluish below. water than th

Darlingford feet; soil, 2 fe Fort Pierre sh in a few hours

Manitou. C the Fort Pierr the surface. I shale at 5 to 13 Saint Leon, to 15 feet deep

to 15 feet deep into shale belo 30 feet deep, surface, Mowbray, Sn

vases going sev water is found Pilot Mound deep, commonl

Rs. 8, 9, and 10

West of Pe southwest of P 150 feet above many get good go 50 to 70 feet. water is found

ssiniboine delta;

, 31 feet, wholly ster rose several

rel, underlain by

ith sandy layers; wart's and George d 120 feet deep, clays and glacial of the deeper of attle.

from 15 to 50 feet of stratified grave

p, in till to shale, erally better from ountered by wells oining Tiger Hills om 2 or 3 to 19 or

et, in tine silt, the quicksand.

ell, 20 feet deep; ne till, 5 feet and

use in sec. 3: well, the boring was in vish, to that depth, he Tiger Hills a

ang's house, see I I, with quicksal of outflow to to

ion of Plum Cred reaching bed-rock Souris near by, rvial and lacustrin

elay, obtaining a scanty supply of water. A boring is said to have been made here for the railway tank, to a depth of 150 feet, without finding a supply of water, and it is now pumped from the Pembina Biver.

Rheinland. Wells 15 to 20 feet deep, in somewhat sandy lacustrine clay; excellent water.

T. 2, R. 5. John Johnston, sec. 3: well, 22 feet; soil, 2 feet; yellowish till, containing boulders up to five feet in diameter, 20 feet; to gravel with water which rises from it two or three feet. This is letween the Campbell and Tintah beaches, on the low terrace at the foot of the Pembina Mountain escarpment. Other wells near show that this terrace consists of the Port Pierre shale, thinly covered with glacial drift.

Morden and Nelson. Wells 10 to 25 feet deep, in till; water frequently alkaline.

Thornhill. The wells of Thornhill and vicinity are 8 to 25 feet deep, their material being till, with sandy streaks from which water seeps. The till is yellowish to a depth of about 15 feet, and dark bluish below. Shallow wells, stopping in the yellow till, have better water than those that pass into the blue till.

Darlingford. David Brown, S. E. ‡ of sec, 6, T. 3, R. 7: well, 30 [set; soil, 2 feet; till, 28 feet, its lowest six feet mostly débris of the Fert Pierre shale; to quicksand at the bottom, from which water rose in a few hours to 10 feet below the surface.

Manitou. Canadian Pacific Railway well, 175 feet deep, wholly in the Fort Pierre shales, excepting about five feet of soil and drift at the surface. The common wells are 20 to 30 feet deep, going into shale at 5 to 12 feet from the surface; water good.

Saint L.con, sees. 34 and 35, T. 4, R. 9. In this village wells are 10 to 15 feet deep, being till to a depth of 6 to 12 feet, and extending into shale below; water good. Other wells in the vicinity are 10 to 30 feet deep, reaching the shale usually less than 15 feet below the surface.

Morebray, Snowflake, and Star Mound. Wells in this district, T. 1 of Rs. 8, 9, and 10, are commonly 15 to 30 feet deep, in till, or in many cases going several feet into the underlying Fort Pierre shale; good water is found in both formations.

Polot Mound. In the village of Pilot Mound wells are 15 to 20 feet deep, commonly passing into the shale at ten feet; water good.

West of Pelican Lake. The deepest wells within a few miles southwest of Pelican Lake, on the nearly level expanse of till about 150 feet above this lake, often reach shale at 25 to 30 or 40 feet; but many get good water at 10 or 15 feet in the overlying till.

GEOLOGIC AND AGRICULTURAL RESOURCES,

The great fertility of the soil in this district, its water-power, the value of its timber for building purposes, manufactures, and fuel, of its stone for construction and lime-burning, and of its deposits of clay for brick-making, are its chief natural resources.

Soliand subsoil.

Over nearly the entire prairie portion of Manitoba, both in the lacustrine area of Lake Agassiz and upon the higher and more undulating or rolling country that stretches thence westward, a sandy clay, often with some intermixture of gravel and occasional boulders forms the soil, which has been colored black to a depth of one or two feet below the surface by decaying vegetation. The alluvial and lacustrine beds, or the glacial drift, the same as the soil, excepting that they are not enriched and blackened by organic lecay, continue below being usually yellowish gray to a depth of ten or fifteen feet, but darket and bluish beyond, as seen in wells. The glacial drift contains many fragments of Cretaceous shale, magnesian limestone, granites, and erystalline schists; and its fine detritus, and the silty deposits carried into Lake Agassiz by its tributaries, are mixtures of these rock pulverized, presenting in the most advantageous proportions the mineral elements needed by growing plants.

Agricultural

Wheat has been the principal crop, but stock-raising and the dairy have also received much attention. A large variety of crops is profitably cultivated throughout the region, including wheat, oats, garden fruits and vegetables, potatoes, and hay. The natural prairie supplies rich pasturage for the herds of the first immigrants; but it is rapidly becoming mainly occupied by farms and brought undecultivation.

Water-power and manufactures. Valuable water-powers are available on many of the streams especially in the wooded northern and eastern portions of Manitoba The rapids and waterfalls of the Winnipeg River, with its magnificent reservoirs of the Lake of the Woods and Rainy Lake, besides a multitude of smaller lakes, will doubtless some day become the sites of large manufacturing cities, where the wheat of the prairies will be mais into flour, and the timber of the adjoining forests will be manufactured into lumber, furniture, and various wooden wares. While agriculture will be the leading occupation in the prairie region, more diversindustries will grow up in the wooded country on the east.

Fuel.

Even the prairie has important resources of fuel in its belts of timber which border streams and lakes, and also extend along the escarpment of the Pembina Mountain and cover the Tiger Hills and Turtle Mountain. With the more full settlement of the prairie, however, some systematic plan may be adopted for securing coal or wood by

eAV.]

railway fre than now. Quarries East Selkir partly for bridges, une mottled and much when newly quari living no st in masonry. is mostly we The Volunte tion of this s situated clos of six or eig applies of s of being quar Stony Mount Similar stone R. 2 E., on la wall. The o

The quarry years ago for to it from the at the time of bed-rock white ollecting and drift through originally decurrents of the drift also comfoundations of Nearly ever

36. T. S. R. 1

are utilized in yards in Saint Winnipeg, probusiness began stripped off to feet of yellowisfor brick-maki tempering. Ti URCES.

vater-power, the s, and fuel, of its osits of clay for

ba, both in the igher and more estward, a sandy ensional boulders. th of one or two The alluvial and il, excepting that y, continue below. n feet, but darke ift contains many ne, granites, and y deposits carriel es of these rocks proportions the

ing and the dairy riety of crops is ding wheat, oats, he natural prairie igrants; but it is d brought unde

of the stream ions of Manitoba ith its magnificent Lake, besides a ecome the sites of airies will be made be manufacture While agriculture ion, more diverse e east.

its belts of timber ng the escarpment Hills and Turtle prairie, however coal or wood by railway freight in large amounts, and therefore at much lower cost

Quarries of magnesian limestone have been extensively worked at Quarried stone. East Selkirk, Stonewall, Stony Mountain, and Little Stony Mountain, partly for lime-burning, but also in large amount for foundations, bridges, and buildings. The East Selkirk stone, which is beautifully mottled and banded, is easy to cut when first quarried, but hardens much when its moisture dries out. It contains so much water that newly quarried blocks in winter are damaged by freezing; but after living no such frost fracture is observed where this rock has been used in masonry. By exposure many years the streaked contrast in color is mostly weathered out, the brown portions losing their darker color. The Volunteers' Monument in Winnipeg is a fine example of the adaption of this stone for ornamental purposes. The quarry at Stonewall, situated close east of the village, has been opened to an average depth of six or eight feet on an area about fifteen rods square. Inexhaustible supplies of stone of the most durable quality, in many portions capable of being quarried in blocks of large dimensions, outcrop there and at Stony Mountain, and have been much used for building in Winnipeg. Similar stone has been slightly quarried on the N.E. 1 of sec. 4, T. 15. R 2 E., on land of Allen Bristow, nine miles north-northeast of Stonewall. The outcrop of Cretaceous limestone on the Assiniboine in sec. 36. T. S. R. 11, has also been quarried in small amount.

The quarry of Little Stony Mountain was actively operated several Lime. rears ago for burning lime, a spur track about a mile long being laid to it from the Canadian Pacific Railway; but work had been suspended at the time of this survey in 1887. Besides the outcrops of the bed-rock which thus supply lime, it is conveniently obtained by collecting and burning limestone boulders that occur in the glacial drift throughout all the prairie district of Manitoba, having been originally derived from these rock-formations and distributed by the currents of the ice-sheet. The more abundant granitic boulders of the drift also commonly serve the immigrant for the construction of foundations of farm buildings and for the walls of cellars and wells.

Nearly every part of the province also has beds of brick-elay, which Bricks. are utilized in proportion to the demands of settlement. Four brickyards in Saint Boniface, on the east side of the Red River opposite to Winnipeg, produced in total in 1887 about four million bricks. This business began to be extensively developed there in 1880. The soil is stripped off to a depth of two feet, beneath which the next two or three feet of yellowish, horizontally laminated, somewhat sandy clay is used for brick-making. It requires no further admixture of sand for tempering. The bricks, which are cream-colored and very durable, are

sold at \$11 to \$12 per thousand, loaded on the cars or delivered in the city of Winnipeg. Another brick-yard in Saint James, close southwest of Winnipeg, makes about 1,500,000 bricks yearly. The light cream color of these bricks, like those of Milwaukee and of most brick-yard in Wisconsin, Minnesota, and North Dakota, is due, as shown by President Chamberlin, to the calcareous and magnesian ingredients of these glacial clays derived in part from magnesian limestone formations, which unite with the iron ingredient to form a light-colored silicate instead of the ferric oxide which in other regions destitute of magnesian limestone gives to bricks their usual red color.

The follow and Lake Su of the ice-sl country whe derived chieff Surveys of C the true or as the observati Minnesota by to have been c

Hudson Str Cape do, Ashe's about do, Cape P to th do, south p do, Digges Ottawa Isla Bay.. East coast a sively do, from Ca

It is probable t eflow during t mmg a somewh elting of the ice East coast of entrane

lat. 58 side of

mostly but in tion ... delivered in the close southwest. The light cream most brick-yards the case shown by an ingredients of stone formations. t-colored silicate, tute of magnesian

APPENDIX I.

COURSES OF GLACIAL STRLE.

The following table of glacial strike in the region of Hudson Bay and Lake Superior and westward shows the directions of the currents of the ice-sheet within the basin of Lake Agassiz and upon the centry where it lay as the barrier or dam of this lake. They are derived chiefly from the reports of the Geological and Natural History Surveys of Canada and of Minnesota, and are all reduced to refer to the true or astronomic meridians. Unless they are otherwise credited, the observations in British America are by Dr. Robert Bell, and in Manesota by the present writer. All are in the area that is supposed to lave been covered by the ice-sheet of the last glacial epoch.

Hudson Strait and Bay.

Huason Stray and Bay.
Hudson Strait, Port Burwell, ten miles southwest from
Cape Chudleigh S. 85° E.
do. Ashe's Inlet, on the north side of the strait,
about S. 65° E.
do. Cape Prince of Wales, on the south side, opposite
to the last E. to N. 70° E.
do, south part of Nottingham Island S. 80° E.
do. Digges Island, off Cape Wolstenholme N. 55°-75° E.
Ottawa Islands, in the northeast part of Hudson
Bay N. 75° E., N. 40°-20° E., and N. 5° W.
East coast of Hudson Bay, northern part, succes-
sively, proceeding southward N. E., N. and N. W.
do, from Cape Dufferin southward to Hopewell Head
and the most northern of Nastapoka Islands, in
lat. 58° to 57° N., near the middle of the east
side of Hudson Bay, numerous localities, S. 70°, 60° and 35° W.
his probable that the first two of these courses record the direction of the
eflow during the time of maximum depth and area of the ice-sheet, o
ring a somewhat later stage; and that the last belongs to the time of fina
elting of the ice.
East coast of Hudson Bay, thence southward to the
entrance of Richmond Gulf, numerous localities,
mostly between S. 65°-75° W. and N. 75° W.
but in two localities, probably a later glacia-
tion S. 35°-45° W.
COU -10 17:

East, Cairn Mountain Island, Richmond Gulf, several
localities, mostly N. 60°-70° W.
but in one place varying from this to S 45° W
do., from Richmond Gulf and Little Whale River
southward to Esquimaux Harbor, many
localities
do, thence to Red Head, fifty-seven miles northeast
of Cape Jones, eight localities W. to S. 75° W.
and one locality S. 55° W.
do., Red Head Island N. 70° W.
do., thence southward to forty miles south of Big
River, many localities
but on the southwest extremity of Long Island,
near Cape Jones, string bear in every direction
from S. 70° W., around by S. W. and S., to S. 40° E.
The two prevailing directions are aboutS. 45° W. and S. 15° E.
the former being probably the older, but perhaps
deflected to the south from the direction of the
glacial current when the ice-sheet was thickest.
and the latter, with further deflection south-
eastward, belonging to the closing stages of the
glacial period. An island off the southwest
point of Long Island has three sets of glacial
striæ S. 60° W., S. 40° W., and S. 20° E.
East coast of Hudson Bay, from forty miles south of
Big River southward along the east coast of the
south half of James Bay, many localities S. 30°-55° W.:
but in one locality, about three miles northwest
of the Paint Hills, three sets of glacial strige
occur, bearing N. 75° W., S. 55° W., and S. 30° W.
The first probably records approximately the course of
glaciation here when the ice attained its greatest
area, belonging thus to a striation which was
chiefly effaced by a later glacial movement to
the southwest during the departure of the ice-
sheet. Again, at the Paint Hills, two sets of
glacial strike are found, bearingS. 75° W. and S. 35° W.;
and on Governor's Island, at the mouth of East-
main River, the course is
Marble Island, northwest part of Hudson Bay S. 15°-25° E.
West coast of Hudson Bay, east side of the mouth of
601 A 131 FD 1
do., two and a half miles east from the last S. 20° W. do., five miles east from the mouth of Churchill
River S. 15° E.

AM-

Region

('hu**r**chill

do., four r Riv do., six ar

Chu Little Chu and Lak

do, outlet fron do, Eagle

the The courses fthe ice-shee

southerly cours
Along the
hunc
its r

do., Broad miles also

do, thence do, Upper portic

do., southw do., Chain-o Lake, the o

do., on Gras the w localit but in

do., between localit

do., Sipi-wes mostly also, in do., Sipi-wesl

southw but in

do., southwes do., from Sip Lake, s

do., Pipestone localitie 8

	Region of the Churchill and Nelson Rivers, Lake Winnipeg, and
V. 60°−70° W.,	southwest to the Assimiboine.
S 45° W.	4. 200 4.00 4.00 4.00
	Churchill River, at Fort Churchill
	do., four miles below the mouth of the Little Churchill
80° W. to W.	River
	do., six and eleven miles above the mouth of the Little
to S. 75° W.,	('hurchill River S. 10°-15° W.
S. 55° W.	Little Churchill River, three localities, four, thirteen
N. 70° W.	and eighteen miles below Was-kai-ow-a-ka
	Lake, respectively S. 40° W., S. 80° W., and N. 85° W.
o and 70° W.:	40., outlet of Lower Recluse Lake, various directions
	from
	do, Eagle F vid, two miles in a straight line below
., to·S. 40° E.	the last, two sets, both distinctS. 20° W. and W.
nd S. 15° E.;	The courses to the west, or nearly so, probably mark the motion of this part
	fthe ice-sheet during the time of its greatest depth and extent; while the
	southerly courses show its deflected motion during the final melting.
	Along the Nelson River, Third Limestone Rapid, a
	hundred miles by the course of the river above
	its mouth
	do., Broad Rapid, five miles long, eleven to sixteen
	miles above the last, mostly
and S. 20° E.	
	do, thence to Middle Gull Rapid, numerous localities. S. 55°-80° W.
	do, Upper Gull Rapid, and thence to the middle
S. 30°-55 W.;	portion of Split Lake, numerous localities N. 85°-75° W. do., southwestern part of Split Lake, two localities S. 85° W.
	do., southwestern part of Split Lake, two localities S. 85° W. do., Chain-of-rocks Rapid, three miles above Split
and S. 30° W.	Lake, one set, probably the older S. 85° W., the other S. 10° E.
	do., on Grass River, tributary to the Nelson River from
	the west a few miles above Split Lake, numerous
	localities
	but in one place, at the outlet of Witchai
	(Stinking) Lake N. 75° W.
	do., between Split Lake and Sipi-wesk Lake, numerous
and S. 35 W.;	localities, mainly
	and occasionally W.
S. 75° W.	do, Sipi-wesk Lake, outlet and northeastern part,
S. 15°-25° E.	mostly S. 70°-75° W.;
	also, in numerous localities S. 45°-65 W.
S. 5° E.	do, Sipi-wesk Lake, average course throughout the
S. 20° W.	southwestern half of the lake S. 55°-60° W.;
	but in some places N. 85° W.
S. 15° E.	do., southwest extremity of Sipi-wesk Lake S. 65° W.
	do., from Sipi-wesk Lake to the outlet of Pipestone
	Lake, six localities S. 55°-65° W.
	do., Pipestone and Big Reed Lakes and vicinity, five
	localities
	8

Along the usual boat route from Hudson Bay by	
Hayes and Hill Rivers to Lake Winnipeg, FIX	
miles below the Rock, Hill River	S. 12° E.
do., the Rock, Hill River	S. 10° E.
set of strice	N. 79° W.
do., Borwick's Fall, and one mile above White-mud	
Fall, Hill River, both within a few miles	
southwest from the Rock, respectively, S. 18° W.,	and S. 28° W.
do., Knee Lake, numerous localities	S. 35°-60° W.
do., from Knee Lake to Pine Lake, seven localities	S. 45°-60° W.
do. from Pine Lake and Molson's Lake to Great	
Playgreen Lake, many localities	S. 35°-60° W.
Around God's Lake, southeast of the foregoing route,	
140 to 180 miles east-northeast from the north	
end of Lake Winnipeg, many localities	
(Cochrane) S. to S. 52° W., mostly	S. 15°-40° W.;
but in two localities	S. 80° W.
Between Jackson Bay, on Oxford Lake, and the	
southern part of God's Lake, seven localities	
(Cochrane)	S. 28°-40° W.
Around Island Lake, about forty miles south of God's	
Lake, many localities (Cochrane)	S. 10°-36° W.
Between Hudson Bay and Lake Winnipeg, along the	
Severn, Fawn, Poplar and Beren's Rivers, on	
almost all exposed rock-surfaces (A. P. Low),	
yarving only a few degrees from this on either	S. W.,
side.	
Mouth of Lake Winnipeg and its vicinity, several	
localities	S. 40°-45° W.
East shore of Lake Winnipeg, Spider Islands, on the	
adjacent mainland, and at the Shoal Islands,	
about thirty and forty-five miles south from the	
north end of the lake	8. 30°-40° W.
do., Poplar Point, four miles southeast of Poplar Point,	
and opposite to George's Island, a few miles	
farther southeast	S. 30°-35° W.
do., four localities near the mouth of Beren's River,	
half-way from the north to the south end of	CI ##0 000 ##
the lake	S. 57°-60° W.
do., near the mouth of Beren's River (Panton)S. V	
do., east side of Beren's or Swampy Island (Panton)	S. W.
do., Rabbit Point, near the Narrows	S. 48° W.
do., Black Bear Island, also near the Narrows	0 6 10
(Panton)	S. S. W.,
intersected by other glacial strine, bearing	S. S. E.
The latter, agreeing in direction with stripe observed	
lountain and Little Stony Mountain, near Winnipeg, app	pear to belong t to

Mountain and Little Stony Mountain, near Winnipeg, appear to belong t

basal portion of southeast in the East shore and t locali Stonewall, in

Stony Mount Little Stony Assiniboine (Upha and in

Athahasca Ri

Mountain Po above t Fort Chipewy

also on Fort Ch Le following of are communic North shore of

the Bur do. twenty m io, half-way lake do, twenty mi

post at 1 do, H. B. pos the east On the western

fifteen m of Athab Junction of Por Wollasto

Lake North shore of western a Jackfish Lake,

and Rein River.... North end of F observatio

do, mouth of H East shore of Re do., half-way fro

lake

	"Myke-"	
	has portion of the divergent glacial current which continued south continued in the Minnesota lobe of the last ice-sheet.	and
S. 12° E.	East shore of Lake Winnipeg, between the Narrows	
S. 10° E.	and the mouth of Winnipeg River, numerous	
N. 70° W.	localities	•
nd S. 28° W.	Assiniboine River, sec. 36, T. 8, R. 11, in three places	
S. 35°-60° W.	(Upham) S. 4°-8° W.,	
S. 45°-60° W.	and in one place S. 10° E.	
S. 35°-60° W.	Athahasca River and Lake, Wollaston and Reindeer Lakes, and southward to Cumbertand House.	l
s. 15°-40 W.;	Mountain Portage, Athabasca River, seven miles above the mouth of Clearwater River	
S. 80° W.	S. 54° E., or more probably N. 54° W Fort Chipewyan, near the mouth of Lake Athabasca,	
S. 28°-40° W.	also one mile west and eight miles southwest of Fort Chipewyan	
S. 10°-36° W.	The following observations, to Cumberland House, are by Mr. A. S. Cochi clare communicated by Dr. Robert Bell, having never before been public	rane, shed.
	North shore of Lake Athabasca, ten miles north from	
	the Burntwood Islands S. 81° W	
S. W.,	twenty miles west of Black Bay S. 61° W.	•
	io, half-way from the west to the east end of the	
	lake S. 43° W	•
	ie, twenty miles west of the Hudson Bay Company's	
S. 40°-45° W.	post at Fond du Lac	
	the east end of the lake S. 53° W	•
S. 30°-40° W.	fifteen miles east from its mouth at the east end	
S. 50 -40 W.	of Athabasca Lake	
S. 30°-35° W.	Wollaston Lake, fifty miles east of Athabasca	
12, 30 =00	Lake S. 75° W	<i>.</i>
S. 57°-60° W.	western and pastern outlets S. 27° W	7.
W. and S. S. W.	lackfish Lake, about half-way between Wollaston	
W. and S. S. W. S. W.	and Reindeer Lakes, by way of Hatchet Lake	
S. 48° W.	River S. 17° W	7.
D. 10 111	North end of Reindeer Lake (average of numerous	
S. S. W.,	observations) S. 31° W	7.
S. S. E.	de, mouth of Hatchet Lake River S. 17° W	
	Part of Daindson Lake Demonstra Daint C 049 W	
at Stonewall, Ston		
pear to belong to the	lake S. 18° W	7.

South end of Reindeer Lake, and on its outlet......

Churchill River, near Frog Portage, 110 miles north-

Charles in the road of the roa	
northwest of Cumberland House S. 40° W.	
do., at a small lake ten miles east from the mouth	
of Isle à la Crosse Lake S. 15° W.	
On the canoe route, seventy miles north of Cumber-	
land HouseS. 16° and 26° W.	
do., fifty-five miles north of Cumberland House	
As on the lower part of Churchill River, before noted, the more wester	v
courses of this list are believed to indicate the glacial motion when the icalia	
its maximum depth, or nearly that, continuing probably through the great	. "
part of the epochs of glaciation; and the southward currents seem referable.	
deflection during the recession of the boundary of the ice-sheet, most of the	
earlier westward strike being thereby effaced.	9
Carried House and State of Carried State	
From Hudson Bay to Lake Superior and the Lake of the Woods,	
On the route of Dr. Bell from James Bay to Lake	
Huron, commonly	
rarely varying to	
Between James Bay and the east end of Lake	
Superior, from Long Portage of the Missinaibi	
River to Mattagami Lake, both belonging to the	
Moose River system, mostly S. S. W.	
do., Wasquagami Portage, Missinaibi River, two	
sets	
The last is doubtless a local deflection, belonging to the time when the	
sheet was being melted away.	
do., Missinaibi River, east of Brunswick Lake	
do., around Mattagami Lake S. 30-65 W	
do., Lake Manitowick, on Michipicoten River S. 30 W.	
do., Long Portage of the Michipicoten River, six	
miles east of its mouth S. 40 W	
North shore of Lake Superior, Falls of St. Mary, and	
theree twenty miles south (Agassiz)	
do., twenty-five miles north of the Falls of St. Mary,	
and thence to the northeast angle of the lake,	•
seventy-five miles east of St. Ignace Island,	
many localities (Agassiz)	
do., fifty miles east of St. Ignace Island (Agassiz) S. S. W.	
do., St. Ignace Island, and the same twenty-five miles east (Agassiz)	ı
do., southwest side of Nipigon Bay (Agassiz) S. S. W.	
do., islands in Thunder Bay (Agassiz)	
do., between Thunder Bay and Pigeon River	
(Agassiz) S.	
Isle Royale, Lake Superior, numerous localities	
(Desor) S. 20'-75 W	
Along the Pic River, tributary to Lake Superior 8. 20°-30° W	
Di at and an analy to a sum o organization of at all all and	

Kenogami Riv

loca

S. 1 . 0 W.

"The groovi valleys." In the con

Seve Along the but Lake St. Je

also, Albanj Ri Man

Maminiska Patawonga Eabamet L Inlet of Stu Attawapish

miles from do, lowest o do, on lim

de, on lime of stri and th

do., on lime about river. do., southern

below and n foregoi Around Lake comme

other ward s and the from...

log Lake, me Lac des Mille Surgeon Lak commo but in c

Minnietakie I several Abram's Chut Islands in the

	math.
S. 18° W.	Kenegami or Long Lake, at the head of the Kenegami
	River, tributary to Albany River, many
S. 40° W.	localities
	The grooving is as well marked on the tops of the highest hills as in the
S. 185 W.	alleys."
6° and 26° W.	In the country northwest of Kenogami or Long Lake,
S. 26° W.	several localities S. 30°-40° W.
the more westerly	Along the Kenogami River, mostly S. 30°-59° W.;
on when the ice had	but varying to
through the greater	Lake St. Joseph, mostly S. 30°-45° W.;
ts seem referable to	also, in two localities S. 15° W. and S. 60° W.
e-sheet, most of the	Albany River between Lake Saint Joseph and
G-Street more of the	Maminiska Lake, three localitiesS. 20°, 25°, and 40° W.
	Maminiska Lake 8. 65° W.
	Patawonga Lake S. 75° W.
f the Woods.	Eabamet Lake, two localities
	Inlet of Sturgeon Lake, Boulder River S. 70° W.
	Attawapishkat River, respectively 3, 13, 22, and 23
E. to S. 51 W.;	miles below the junction of the two channels
S. 25° E.	from the lake of the same nameS. 60°, 42° 22°, and 15° W.
	lowest exposure of Archean rocks S. to S. 10° E.
i	do, on limestone about 75 miles from the southern
3	mouth of the river
S. S. W.	de, on limestone nine miles below the last, two sets
0	of strine, the older S. 8°-12° W.;
W., and S. 60° E	and the newer
he time when the v	do, on limestone at the head of Lowasky Island,
AIN. CILLERY WITH THE PARTY OF	about 44 miles from the southern mouth of the
8. 15° E	river S. 2° W.
S, 30-65° W	do, southern channel or Lowasky River, four miles
P One W	below the last, the older strice S. 35° W.;
ix	and newer strike varying in course from the
C 100 W	
nd S. S. E	Around Lake Nipigon two sets of glacial striæ are
	common, and are often found crossing each
ry,	other on the same rock surface. The south-
ke,	ward set, which is the older, varies from S. 18° E. to S. 25°. W.;
id,	and the westward and newer set varies
C 1 11	from
	Along and near Kaministiquia Rive S. to S. W., averaging S. S. W.
les	Fig Lake, mean of several localities (Hector) S. 10° W.
S.	Lac des Mille Lacs, mean of several localities (Hector) S. 5° E.
S. S. W.	ingent rate, my miles southeast of honory many
s. w	commonly S. 20°-30° W.;
ver	but in one locality S. 50° W.
8	Minnietakie Lake and vicinity, west of Sturgeon Lake,
ties	several localities 8. 20°-55° W.
8. 20°-75° W	Apparis Chille
S. 20°-30° /	Islands in the middle of Abram's Lake S. 40° W.

Lonely Lake (Lac Seul), three localities
do., three other localities, respectively 10, 13, and 16
miles east of the Hudson Bay Company's post.
do., east extremity of the lake S. 45° W.
Root River, tributary to the east end of Lonely Lake,
two localities S. 50° and 45° W.
English River, below Lonely Lake, five localities S. 30°-60 W
and one locality S. NO W.
Winnipeg River, several localities S. 20° 556 W
Around the Lake of the Woods, observations in about
180 localities by Dr. A. C. Lawson and assistants,
and in about 60 localities reported by Dr. G. M.
Dawson, "the great majority," i.e., 82 per cent. S. 35°-55° W.
but 13 per cent. are S. 10°-31 W.
and 5 per cent. are S. 56°-83° W
Only four localities showed courses more westerly
than S. 65° W.: one of these is on the southeast
side of Big Island, where strike bearing S. 75° W.
intersect others bearing S. 37° W.;
on the west side of Bigsby Island, which, like
the preceding, lies near the middle of Sand
Hill Lake (the southern and largest part of the
Lake of the Woods), double sets of strice were
observed in two places, respectivelyN. 80° W. and S. 20° W.
and N. 83° W. and S. 33° W.
and on a point projecting from the south shore
in the southwestern part of this Sand Hill Lake,
striæ bear
with others
Probably the bearings S. 10° E. to S. 20° or 30° W. belong to the time f
maximum depth and area of the ice-sheet; the prevailing southwestern course
to later glaciation; and the more westerly deflections to the time of final means of the ice.
Minnesota.
North shore of Lake Superior southwesterly from

North shore of Lake Superior southwesterly from	
Pigeon Point, numerous localities (Norwood and	
Whittlesey)	S. 25°-45° W.
Duluth (N. H. Winchell)	W. S. W.
Otter Track, Sucker (or Carp), and Long Lakes, in	
northeastern Minnesota, south of Hunter's	
Island (Winchell)	S. W.
Vermilion Lake, two places (Winchell), about	S. 20° W.,
and in another place (Winchell)	8. 40° W.
Vermilion Lake (Whittlesey)	S. 15° W.
Pike River, tributary to Vermilion Lake, two places	
(Winchell)	10° and 20 W.

, zieklie]

In T. 59, Ve The follows

Winchell, not Vermilio do., three Birch Lai Sec. 30, T Sec. 27, T. Basswood Ima Lake

Island in Sec. 11, T.

Knife Lak
The two foll
report, for 1887
East end o
Island in 1
Mr. Horace

ariation:—
Little Fork
Rainy Rive
Rainy Lak
North fall
Lake
Bowstring 1

in T.
do., a shori glacia
Deer River
juncti
T. 62,

Big Fork, ab River do., in or ne The southeastv 1 dk belongs to t subeast from the ballers and gra Ed liver Valley

Lower Falls Elbow Lake, Pelican Lake localitie Net Lake, in

Trout Lake, in

	Surfa.
	In T. 59, R. 14, about twenty miles south-southeast of
and N 80° W.	Vermilion Lake (Winchell), estimated S. 30° W.
	The following, to Knife Lake, inclusive, are observations by Prof. N. H. Winchell, noted in his Fifteenth annual report, Minn., 1886, pp. 385-6:
and S. 55° W.	Vermilion Lake, twenty localities
8, 45° W.	do, three other localities
	ßirch Lake
50° and 45° W.	S. 8° E.
S. 30°-60° W.	Sec. 35, T. 63, R. 9
S. 80 W.	Sec. 27, T. 63, R. 10
S. 20°-55° W.	Basswood Lake, Northeast Cape
14 20 110 11.	
	Ima Lake, north shore
	Island in Thomas Lake S. 25° W.
S. 35°-55° W.;	Sec. 11, T. 64, R. 7 S. 30° W.
	Knife Lake S. 48° W.
S. 10°+34° W.,	The two following are from Prof. N. H. Winchell, in his Sixteenth annual
S. 56°-83° W.	report, for 1887, p. 114:
	East end of Delta Lake, west of Ogishke Muncie Lake. S. 25° W.
44 May 200	Island in Pseudo-Messer Lake S. 40° W.
S. 75° W.	Mr. Horace V. Winchell, in the report last cited, pp. 395-478, notes the
S. 37 W.;	following glacial strice, to Trout Lake, inclusive, corrected by him for magnetic
	initiation:—
	Little Fork of Rainy River, five localities S. 10°-42° W.
	Rainy River, 31 miles below Fort Francis 8. 32° W.
	Rainy Lake, nine localities
7. and 8. 20 W.,	North fall on outlet from Namekan Lake to Rainy
', and S. 33° W.;	Lake S. 30° W.
3	Bowstring River (Big Fork of Rainy River), probably
),	in T. 63, R. 26, intersecting strice, mainly as 10° W. and S. 30° E.
. 70° and 65° W.	
V.; also, S. 10° E.	do, a short distance above the last, very distinct
belong to the time of	glaciation
southwestern courses	Deer River, at dam about a half mile above its
e time of final melting	junction with the Big Fork, probably in
	T. 62, R. 25
	Big Fork, about three miles above the mouth of Deer
	River Due E.
	do., in or near sec. 35, T. 150, R. 25 S. 52° E.
p.	The southeastward and eastward striation on the Bowstring River or Big
1	lak belongs to the east part of the glacial current that moved to the south and
S, 25°-45° W.	sulleast from the region of Lakes Winnipeg and Manitoba, carrying plentiful
W. S. W.	tallers and gravel of limestone from those lakes and the lower part of the
1	Red River Valley southeast to this stream and to the mouth of Rainy Lake.
s	Lower Falls of Prairie River, sec. 34, T. 56, R. 25 8.
S. W.	Elbow Lake, T. 64, R. 18, two localities S. 26° W. and S. 28° W.
S. 20° W.	Pelican Lake, mostly in Ts. 64 and 65, R. 20, four
≤. 40° W.	localities 8. 24°-36° W.
S. 15° W.	Net Lake, in the Bois Fort Indian Reservation 8. 20°-24° W.
4	Trout Lake, north of Vermilion Lake, two localities.
. 10° and 20° W.	
AU min -	

Sand Point Lake and Sturgeon or Namekan Lake
(Whittlesey)S. W. to S. 55 W.
Rainy Lake (Whittlesey)
Big Fork of Rainy River, about 82 miles from its
mouth (Whittlesey)
This seems to be near the locality noted by H. V. Winchell about three mile
above the mouth of Deer River.
Hinckley, Pine County S. and S. 5 W.
Watab, Benton County S. 15 W.
Sauk Rapids, Benton County, numerous places 8, 45°-55 W.
but in one place S. 15 W.
Sauk Center, Stearns County, forty miles west of the
last S. 40 E.
Minneapolis, several places S. 5°-28 E.
One to seven miles southeast from Big Stone Lake,
numerous pla. s S. E.
Granite Falls, several places S. 45 - 50° E.
Beaver Falls S. 60 E.
In the valley of the Minnesota River two miles below
Lirch Cooley S. 60 E.
One and a half miles west of Fort Ridgely
Redstone, near New Ulm S. 25 E.
Jordan, at mill of Foss, Wells & Co S. E.
Posen, Yellow Medicine County S. 50 E.
Echo, Yellow Medicine County S. 50'-55 E.
T. 111, R. 38, Redwood County S. 50 ² -60 E.
Stately, Brown County S. 50°-55° is.
Germantown, Cottonwood County S. 30° E., S. 50° E., and S. 70° E.
Amboy, Cottonwood County, mostly S. 35°-50° E.
but also rarely deflected to S. 70 E.
In one place all these courses intersect on the same surface.
Delton, Cottonwood County, numerous localities,
mostly S. 15°-40 E;
also, in one place, all courses from S. to S. 80 E.,
intersecting on the same surface.
Selma, Cottonwood County S. 18°-22 E.
Amo, Cottonwood County S. 30°-32 E
Pale, Cottonwood County S. 20°-34° E.
Adrian, Watonwan County S 20'-30 E.
·

n Lake Agas to each other been used as are found to a their reliabilit leginning of exceeding five their profiles have copied fr tabulated; but del from the aken much in rateful ackno The plane of tated through nilways design ummits from v fbridges. Th oted when it is rdinary low st Altitudes of water-shed, w ternational b msultation. I Tthis Survey, a ¤peditions, wl ilway surveys ese to the sea ses, whether o

id the amount arit, are noted.

Much care

APPENDIX II.

TABLES OF ALTITUDES.

Much care has been taken to determine the elevations of the beaches Altitudes Lake Agassiz with the greatest possible accuracy, in their relation rail each other and to the sea level. The railway surveys which have hen used as the basis for my levelling along these ancient beaches getound to agree very closely with each other, giving assurance of their reliability throughout the basin of Lake Agassiz, as stated at the leginning of this report, within probable limits of error nowhere exceeding five feet. By the courtesy of the engineers of these railways, heir profiles have been mostly submitted to my examination, and I are copied from them the greater part of the notes which are here abulated; but small portions have been received in manuscript compled from the profiles by the engineers or their assistants, who have aken much interest in this work, and to whom I desire to express my rateful acknowledgments.

The plane of reference in the following tables, and for the altitudes Reference to ate throughout this report, is the mean tide sea level. Heights on level. niways designate the top of the rail in front of passenger stations, at ammits from which the grade descends both ways, and at the middle flyidges. The lowest and highest known stages of water in rivers is ted when it is given on the profiles; but in many instances only the dinary low stage is recorded.

Altitudes of lakes, rivers, hills, mountains, and depressions in lines Lakes, rivers, water-shed, within the basin drained to Lake Agassiz north of the lines of water-shed. ternational boundary, are also here tabulated for convenient usultation. Portions of these lists are compiled from former reports this Survey, and from Hind's Narrative of the Canadian Exploring speditions, which was published in 1860. Wherever subsequent lway surveys have supplied means for more accurate reference of ise to the sea level, the needed corrections have been made. In all ses, whether of railways or other lists, the source of observations, the amount of change from the original, if any, with the reasons rit, are noted.

ace. S. 15°-40° E; S. to S. 80° E.,

, to S. 55 W. and W. S. W. S. 80° E. ll about three miles

and S. 5 W. S. 15° W. S. 457-55 W.;

> S. 15° W. S. 40 E.

S. 5°-28 E.

S. 45 -50° E.

S. E.

S. 60 E.

S. 60 E.

S. 60° E.

S. 25 E.

S. 50 E.

S. 503-55 E.

S. 50°-60 E. S. 50°-55° E.

and S. 70° E.

S. 35°-50° E.;

S. 70° E.

S. E.

S. 18 -22 E. S. 305-32 E S. 20°-34° E. S 20 -30 E.

CANADIAN PACIFIC BAILWAY,

A published profile of this railway gives the elevation of Lake Su; erior as Sec. feet above the sea, while on the profiles in the engineers' offices it is shown as 600 feet. Assuming the mean of these figures to represent the mean lake leve. a uniform addition of three feet is here made to the eastern part of the profile extending from Port Arthur to Eagle River station, to accord approximately with the mean elevation of Lake Superior, 601.56, determined by the Units States Lake Survey.

The profile shows a discrepancy of eight feet close west of Eagle River staffer 232 miles west of Port Arthur, on account of which its elevations thence west Cross Lake require a subtraction of five feet, which is here made, to agree with the foregoing. Again at Cross Lake, 334.4 miles west from Port Arthur, a discrepancy of five feet to be added is found in the profile, so that its original elevations thence west to the Red River and south to Emerson are here copied without change, being in accord with the corrected profile on the east.

The main line from East Selkirk to the junction of the Emerson branch da east of Winnipeg, and this branch, extending from Saint Boniface to the international boundary, are supplied by Collingwood Schreiber, chief engine and general manager of the Canadian government railways, and are on the same system of levelling with the main line from Port Arthur to East Selker which, however, is subject to the slight adjustments mentioned. This will series thus adjusted is surely correct within very close approximation, as shown by its exact agreement at Emerson with the Saint Paul, Minneapolis Manitoba Railway and with levelling by the United States Engineer Con along the Red River of the North.

Two smaller discrepancies also appear in the profile, but are here neglected At 117 miles from Port Arthur (close west of Scott's River) and thence west subtraction of two feet is indicated; and at 256.5 miles (close west of Parrywand thence west, a subtraction of one foot. If these were taken into account the west part of this profile would be lowered three feet; but it seems more probathat it should agree with the elevation of Emerson determined by surveys the United States.

A large discrepancy is found between the eastern system of levelling and which begins at Winnipeg and extends west to the Rocky Mountains. I latter includes the branches west of the Red River at Winnipeg and westwar also the Manitoba & Northwestern Railway and its branches, which refer the elevations to that of the Canadian Pacific profile at Portage la Prairie. system east of the Red River is reliable, as already stated; and levelling for Saint Boniface station (754 feet) to the Louise bridge (752 feet, instead of 728) the profile extending westward) shows that the system west of the Red Riv requires a uniform addition of twenty-four feet, which is here made in thelis of elevations at Winnipeg and thence west. With this correction, the Soci western Branch from Winnipeg to Gretna agrees with the Saint Pa Minneapolis & Manitoba Railway at the international boundary; the sure from this branch at Rosenfeld to Emerson agrees with the Emerson bra : and the West Selkirk branch agrees with the main line east of the Red Riv

Between 1 Peterson, eng Fast Selkirk

milways. Ott Lake Sup 1888,

Ste.

Lake Sup 4.9 fee Port Arth Mont

McIntyre Neebing of Fort Willia Kamii

mon Wate Fort Willia Kaministic water.

Murillo ... Summit, gr Lofoden ... Depression, sammit, eu Strawberry 990-993

Kaministiq Kaministiqu 982-996 Mattawan 1 1082-108

Smshine Cr high wa Sunshine Cre high wa Finmark

Sunshine Cre Buda (a sur same) .. Oskondiga R

Tunnel, grad Oskondiga R Nordland Summit, natt

a. Main line, from Port Arthur to Winnipeg.

Between Port Arthur and East Selkirk from profiles in the offices of P. A. Paterson, engineer, Montreal, and R. M. Pratt, engineer, Winnipeg; and between Fast Selkirk and Winnipeg from Collingwood Selveiber, engineer of government citiaws. Ottawa.

i	ways, Ottawa.			
	16	Miles from ort Arthur.	Feet above the sea.	
	Lake Superior, mean surface, Nov. 1, 1870, to Jan. 31,			
	1888, according to U.S. Engineers' gauge, Sault			
	Ste. Marie	0.0	601.56	
	Lake Superior, extreme low and high water (range,			
	4.9 feet), approximately	0.0	599-004	
	Port Arthur (a summit of grade), 993.0 miles from			
	Montreal		628	
	McIntyre or Second River, water, 603; grade		610	
	Neebing or First River, water, 603; grade	6.3	610	
	Fort William	7.0	615	
	Kaministiquia River here, 11 miles above its			
	mouth, bed, 586; low water (1879), 600; high water (1859), 612.	1		
	Fort William West (station disused)	10.0	635	
	Kaministiquia River here, bed, 584; low and high		0.55	
	water	10.0	602-614	
	Murillo	17.6	947	
	Summit, grade (three feet above natural surface)	20.6	1080	
	Lofoden	20.8	1078	
	Pepression, filling 7 feet : grade	21.8	1055	
	Summit, cutting 2 feet; grade	20.3	1081	
	Strawberry Creek, bed, 987; low and high water,		1031	
	990-993; grade	27.3	1002	
	Kaministiquia		1013	
	Kaministiquia River, bed, 973; low and high water,		1010	
	982-996; grade		1013	
	Mattawan River, bed, 1078; low and high water,		101.5	
	1082-1089; grade	32.4	1099	
	Sunshine Creek, first crossing, bed, 1106; low and		1099	
	high water, 1109-1113; grade	33.9	1122	
	Sunshine Creek, third crossing, bed, 1151; low and		1122	
	high water, 1158-1162; grade		2.1.11	
	Finmark	35.5	1168	
		37.1	1180	
	Sunshine Creek, bed, 1330; water, 1334; grade		1352	
	Buda (a summit, natural surface and grade the			
	same)		1473	
	Oskondiga River, bed, 1415; water, 1421; grade	45.3	1453	
	Tunnel, grade, 51 feet below top of rock above	46.1	1458	
	Oskondiga River, bed, 1426; water, 1428; grade	52.2	1441	
	Nordland	0.5, 0.6	1543	
	Summit, natural surface and grade	57.8	1584	

mined by the United
of Eagle Riverstates,
vations thence west to
made, to agree with
from Port Arthur, a
ille, so that its origes,
nerson are here copied

Lake Su; erior as Su

offices it is shown as

the mean lake level.

rn part of the profile coord approximately

on the east.
Emerson branch clost
saint Boniface to the
preiber, chief enginer
ways, and are on the
Arthur to East Selvis,
entioned. This whole
approximation, as in
t Paul, Minneapolis a
States Engineer Con-

but are here neglected, er) and thence west, a ose west of Parrywes, taken into account to it seems more probals armined by surveys;

m of levelling and the ocky Mountains. To innipeg and westwalt ches, which refer the ortage la Prairie. 1 ed; and levelling for 2 feet, instead of 72 west of the Red like here made in the fix correction, the Sout with the Saint Pathoundary; the same the Emerson brand east of the Red Rive.

Southeast branch of Savanne River, bed, 1544; water, 1545; grade 59.9 1554 Southeast branch of Savanne River, bed, 1537; water, 1538; grade 62.0 1546 Linkooping 65.2 1534 Savanne 75.8 1506 North branch of Savanne River, bed, 1487; water, 1489; grade 76.4 1506 Usala 86.2 1579 Carlstad 93.6 1515 Fire-steel River, bed, 1500; water, 1505; grade 98.5 1515 Fire-steel River, bed, 1519; water, 1525; grade 102.2 1532 Bridge River station 103.6 1542 Hawk Lake, water, 1509; grade 113.6 1545 English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1517 Scott's River, bed, 1505; water, 1511; grade 116.0 1517 Scott's River, bed, 1505; water, 1511; grade 116.0 1556 Summit, cutting 11 feet; grade 123.6 1556 Summit, grade 131.6 1556 Summit, grade 134.0 1552 <t< th=""><th>Pe</th><th>Miles from ort Arthur.</th><th>Feet above the sea.</th></t<>	Pe	Miles from ort Arthur.	Feet above the sea.
Southeast branch of Savanne River, bed, 1537; water, 1538; grade 62.0 1546 Linkooping 65.2 1534 Savanne 75.8 1506. North branch of Savanne River, bed, 1487; water, 1489; grade 76.4 1506. Upsala 86.2 1579 Carlstad 86.2 1579 Carlstad 93.6 1515 1515 Beaver River, bed, 1500; water, 1505; grade 98.5 1515 Beaver River, bed, 1519; water, 1525; grade 98.5 1515 Beaver River, bed, 1519; water, 1525; grade 102.2 1532 Bridge River station 103.6 1543 Hawk Lake, water, 1509; grade 113.6 1543 Hawk Lake, water, 1509; grade 115.2 1515 English River, bed, 1504; water, 1510; grade 116.0 1517 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 1545 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1550 Summit, grade 134.0 1550 Summit, grade 134.0 1550 Summit, grade 135.4 1551 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 1478 Gull River, bed, 1456; grade 143.7 1496 Falcon 144.8 1554 Summit grade 155.3 1560 Ahgimac River, bed, 1470; grade 155.3 1487 Osaquan River, bed, 1398; grade 158.7 1498 Butler 152.3 1487 Osaquan River, bed, 1398; grade 166.5 1466 Habitate Wabigoon River, bed, 1398; grade 167.0 1466 Raleigh 170.4 1446 1560 1560 1560 1560 1560 1560 1560 156			
Linkooping		59.9	1554
Savanne 75.8 1506 North branch of Savanne River, bed, 1487; water, 1489; grade 76.4 1506 Upsala 86.2 1579 Carlstad 93.6 1515 Fire-steel River, bed, 1510; water, 1505; grade 98.5 1515 Beaver River, bed, 1519; water, 1525; grade 102.2 1532 Bridge River station 103.6 1548 Hawk Lake, water, 1509; grade 113.6 1548 English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1531 Scott's River, bed, 1505; water, 1511; grade 116.0 1545 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bontheur 134.0 1539 Suth Lake, water, 1495; grade 136.4 1541 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1456; grade 143.7 1546		62.0	1546
North branch of Savanne River, bed, 1487; water, 1489; grade	Linkooping	65.2	1534
1489; grade	Savanne	75.8	1506
Upsala 86.2 1576 Carlstad. 93.6 1545 Fire-steel River, bed, 1500; water, 1505; grade 98.5 1543 Beaver River, bed, 1519; water, 1525; grade 102.2 1552 Bridge River station 103.6 1548 Hawk Lake, water, 1509; grade 113.6 1548 English River, bed, 1504; water, 1510; grade 115.2 1545 English River, bed, 1505; water, 1511; grade 116.0 1547 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1482 Summit, grade 131.6 1549 Bonheur 136.4 1559 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 1478 Gull River, bed, 1456; grade 143.7 1496 Falcon 144.8 1540 Ahgimac River, bed, 1398; grade 151.3 1496 Osaquan River, bed, 1398; grade 158.7 1426	North branch of Savanne River, bed, 1487; water,		
Carlstad 93.6 1545 Fire-steel River, bed, 1500; water, 1505; grade 98.5 1543 Beaver River, bed, 1519; water, 1525; grade 102.2 1562 Bridge River station 103.6 1543 Hawk Lake, water, 1500; grade 113.6 1543 English River, bed, 1504; water, 1510; grade 115.2 1545 English River station 116.0 1547 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 134.0 1530 Summit, grade 138.3 1540 Depression, grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1456; grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1470; grade 152.3 1485 Osaquan River, bed, 1398; grade	1489; grade	76.4	1500
Carlstad 93.6 1545 Fire-steel River, bed, 1500; water, 1505; grade 98.5 1543 Beaver River, bed, 1519; water, 1525; grade 102.2 1532 Bridge River station 103.6 1543 Hawk Lake, water, 1500; grade 113.6 548 English River, bed, 1504; water, 1510; grade 115.2 1545 English River, bed, 1505; water, 1511; grade 116.0 1547 Scott's River, bed, 1505; water, 1511; grade 116.6 1548 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Summit, grade 136.4 1550 Summit, grade 136.4 1550 Summit, grade 136.4 1550 Summit, grade 138.3 1540 Depression, grade 139.7 145 Gull River, bed, 1456; grade 143.7 1196 Falcon 144.8 1506 Ahgimac River, bed, 1	Upsala	86.2	1579
Fire-steel River, bed, 1500; water, 1505; grade 98.5 151: Beaver River, bed, 1519; water, 1525; grade 102.2 152: Bridge River station 103.6 154: Hawk Lake, water, 1509; grade 113.6 151: English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1547 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 155 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 134.0 1530 Summit, grade 138.3 1540 Summit, grade 138.3 1540 Depression, grade 138.3 1540 Summit, grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1456; grade 143.7 1490 Gull River, bed, 1456; grade 152.3 1485 Osaquan River, bed, 1398; grade <th>Carlstad</th> <th>93.6</th> <th></th>	Carlstad	93.6	
Beaver River, bed, 1519; water, 1525; grade 102.2 1532 Bridge River station 103.6 1543 Hawk Lake, water, 1509; grade 113.6 1545 English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1547 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 136.4 1551 South Lake, water, 1495; grade 138.3 1540 Boult Lake, water, 1495; grade 139.7 147 Guil River, bed, 1456; grade 143.7 1190 Falcon 144.8 1506 Ahgimac River, bed, 1470; grade 151.3 186 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 165.7 1408 Glencoe River, bed	Fire-steel River, bed, 1500; water, 1505; grade	98.5	
Bridge River station 103.6 1543 Hawk Lake, water, 1500; grade 113.6 1518 English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1517 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1537 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 136.4 1551 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 1178 Gull River, bed, 1456; grade 143.7 1190 Falcon 144.8 1500 Ahgimac River, bed, 1470; grade 151.3 1180 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 160.5 1423 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1406 Raleigh 170.4 <th>Beaver River, bed, 1519; water, 1525; grade</th> <th>102.2</th> <th></th>	Beaver River, bed, 1519; water, 1525; grade	102.2	
Hawk Lake, water, 1509; grade 113.6 1518 English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1547 Scott's River, bed, 1505; water, 1511; grade 116.6 1546 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1482 Summit, grade 131.6 1549 Bonheur 136.4 1559 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 1478 Gull River, bed, 1456; grade 143.7 1199 Falcon 144.8 1509 Ahgimac River, bed, 1470; grade 151.3 1499 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1420 Butter 160.5 1423 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1465 Glencoe River, bed, 1398; grade 180.0 1266 Glacké 168.6<		103.6	
English River, bed, 1504; water, 1510; grade 115.2 1515 English River station 116.0 1517 Scott's River, bed, 1505; water, 1511; grade 116.6 1516 Summit, cutting 11 feet; grade 123.6 1555 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Summit, grade 131.6 1549 Summit, grade 131.6 1549 Summit, grade 134.0 1520 Summit, grade 134.0 1520 Summit, grade 138.3 1540 Depression, grade 138.3 1540 Depression, grade 138.3 1540 Depression, grade 138.3 1540 Depression, grade 138.7 1458 Gull River, bed, 1456; grade 143.7 1493 Gull River, bed, 1456; grade 151.3 1490 Ignace 152.3 1487 Osaquan River, bed, 1470; grade 158.7 1420 Butler 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1420 Butler 160.5 1425 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1406 Raleigh 170.4 1440 Little Wabigoon River, bed, 1350; grade 180.0 1526 Burnt Stick Creek, bed, 1344; grade 182.5 1537 Kirkpatrick Creek, bed, 1314; grade 182.5 1537 Kirkpatrick Creek, bed, 1320; grade 188.9 1552 Burnt Stick Creek, bed, 1320; grade 188.9 1552 Burnt Stick Creek, bed, 1320; grade 198.6 1534 Brulé 190.4 1555 Brulé 190.4 1555 Marian River, bed, 1198; grade 200.4 200.8 1253 Hughes River, bed, 1198; grade 202.2 1241 Wabigoon 202.6 1241 Thunder Creek, bed, 1200; grade 204.5 1245 Thunder Creek, bed, 1200; grade 206.1 1225		113.6	
English River station			
Scott's River, bed, 1505; water, 1511; grade 116.6 1556 Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1555 Martin 127.4 1485 Depression, grade 127.4 1485 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 136.4 1554 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1456; grade 143.7 1190 Falcon 144.8 1506 Ahgimac River, bed, 1470; grade 151.3 1890 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1420 Buther 160.5 1423 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1406 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1356 Burnt Stick Creek, bed, 1314; grade 182.5 1337 <th></th> <th></th> <th></th>			
Summit, cutting 11 feet; grade 123.6 1558 Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 136.4 1554 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1456; grade 143.7 1170 Falcon 144.8 1500 Ahgimac River, bed, 1470; grade 151.3 1860 Ahgimac River, bed, 1470; grade 151.3 1860 Butter 152.3 1487 Osaquan River, bed, 1398; grade 160.5 1423 Little Wabigoon River, bed, 1398; grade 167.0 1465 Raleigh 170.4 1446 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1256 Burnt Stick Creek, bed, 1314; grade 180.0 1256 Burnt Stick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 124			
Martin 124.0 1557 Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 136.4 1551 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 1178 Gull River, bed, 1456; grade 143.7 1196 Falcon 144.8 1566 Ahgimac River, bed, 1470; grade 151.3 1186 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1426 Butter 160.5 1425 Little Wabigoon River, bed, 1398; grade 167.0 1465 Glencoe River, bed, 1398; grade 167.0 1465 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1356 Taché 180.2 1556 Burnt Stick Creek, bed, 1314; grade 182.5 1347 Kirkpatrick Creek, bed, 1320; grade 183.9 1552			
Depression, grade 127.4 1483 Summit, grade 131.6 1549 Bonheur 134.0 1530 Summit, grade 136.4 1551 Summit, grade 138.3 1540 South Lake, water, 1495; grade 138.3 1540 Depression, grade 139.7 147 Gull River, bed, 1456; grade 143.7 1190 Falcon 144.8 1506 Ahgimac River, bed, 1470; grade 151.3 1490 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1420 Butler 160.5 1425 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1466 Raleigh 170.4 146 Little Wabigoon River, bed, 1350; grade 180.0 1366 Burnt Stick Creek, bed, 1314; grade 182.5 133 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 133; grade 196.6			
Summit, grade 131.6 1549 Bonheur 134.0 1520 Summit, grade 136.4 1551 South Lake, water, 1495; grade 139.7 147 Gull River, bed, 1456; grade 139.7 147 Gull River, bed, 1456; grade 143.7 1490 Falcon 144.8 1500 Ahgimac River, bed, 1470; grade 151.3 1480 Algance 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1420 Butler 160.5 1423 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1405 Raleigh 170.4 1446 Raleigh 180.0 1396 Burnt Stick Creek, bed, 1344; grade 180.0 1396 Burnt Stick Creek, bed, 1314; grade 182.5 1347 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 133; grade 190.4 135 McHugh's Creek, bed, 1207; grade 19			
Bonheur 134.0 135.0 Summit, grade 136.4 135.1 South Lake, water, 1495; grade 138.3 150.0 Depression, grade 139.7 147. Gull River, bed, 1456; grade 143.7 119.0 Falcon 144.8 150.0 Ahgimac River, bed, 1470; grade 151.3 1190.0 Ignace 158.7 1420.0 Osaquan River, bed, 1398; grade 160.5 1425.0 Butler 160.5 1425.0 Little Wabigoon River, bed, 1398; grade 167.0 1465.7 Glencoe River, bed, 1398; grade 167.0 1465.7 Raleigh 170.4 1446.0 Little Wabigoon River, bed, 1350; grade 180.0 1366.0 Taché 180.2 1500.0 Burnt Stick Creek, bed, 1314; grade 182.5 1347.0 Kirkpatrick Creek, bed, 133; grade 183.9 1552.0 Bear Creek, bed, 133; grade 186.6 1348.0 Brulé 190.4 155.0 McHugh's Creek, bed, 1207; grade			
Summit, grade 136.4 1554 South Lake, water, 1495; grade 138.3 1546 Depression, grade 139.7 147. Gull River, bed, 1456; grade 143.7 117. Gull River, bed, 1456; grade 144.8 1566 Falcon 144.8 1566 Ahgimac River, bed, 1470; grade 151.3 1186 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 168.7 1426 Butler 160.5 1423 Little Wabigoon River, bed, 1398; grade 167.0 1465 Glencoe River, bed, 1398; grade 167.0 1466 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1256 Burnt Stick Creek, bed, 1314; grade 180.2 1256 Burnt Stick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 1248 Brulé 190.4 155 Bear Creek, bed, 1207; grade 198.6 1245 Summit, grade 200.4 200.8 1253 Hughes River, bed,			
South Lake, water, 1495; grade 138.3 150 Depression, grade 139.7 1478 Gull River, bed, 1456; grade 143.7 1190 Falcon 144.8 1500 Ahgimac River, bed, 1470; grade 151.3 1490 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1420 Butter 160.5 1423 Little Wabigoon River, bed, 1398; grade 167.0 1468 Glencoe River, bed, 1398; grade 167.0 1468 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1356 Raché 180.2 1566 Burnt Stick Creek, bed, 1314; grade 182.5 1547 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 1348 Brulé 190.4 155 McHugh's Creek, bed, 1207; grade 198.6 1245 Summit, grade 200.4-200.8 1253 Hughes River, bed, 1198; grade 200.4-200.8 1253 Hughes River, bed, 1200; grade<			
Depression, grade 139.7 145 Gull River, bed, 1456; grade 143.7 1196 Falcon 144.8 1506 Ahgimac River, bed, 1470; grade 151.3 1496 Ignace 152.3 1187 Osaquan River, bed, 1398; grade 158.7 1420 Butler 160.5 1425 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1405 Raleigh 170.4 1146 Little Wabigoon River, bed, 1350; grade 180.0 1366 Taché 180.2 1366 Burnt Stick Creek, bed, 1314; grade 182.5 1347 Kirkpatrick Creek, bed, 1320; grade 183.9 1352 Bear Creek, bed, 1333; grade 196.6 1348 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 1273 Hughes River, bed, 1198; grade 200.4–200.8 1273 Hughes River, bed, 1200; grade </th <th></th> <th></th> <th></th>			
Gull River, bed, 1456; grade 143.7 11% Falcon 144.8 150% Ahgimac River, bed, 1470; grade 151.3 1186 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1426 Butler 160.5 1425 Little Wabigeon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1405 Raleigh 170.4 1446 Little Wabigeon River, bed, 1350; grade 180.0 1356 Burnt Stick Creek, bed, 1314; grade 182.5 1337 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 1348 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 125 Hughes River, bed, 1198; grade 202.2 1211 Wabigoon 202.6 1211 Thunder Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Falcon 144.8 1506 Ahgimac River, bed, 1470; grade 151.3 1496 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1426 Butler 160.5 1425 Little Wabigoon River, bed, 1398; grade 165.7 1466 Glencoe River, bed, 1398; grade 167.0 1466 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1356 Taché 180.2 1506 Burnt Stick Creek, bed, 1314; grade 182.5 1507 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 1348 Brulé 190.4 1555 McHugh's Creek, bed, 1207; grade 198.6 1255 Summit, grade 200.2 1241 Hughes River, bed, 1198; grade 202.2 1241 Wabigoon 202.6 1241 Blackwater Creek, bed, 1200; grade 204.5 1241 Thunder Creek, bed, 1205; grade			
Ahgimac River, bed, 1470; grade 151.3 1496 Ignace 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1426 Butler 160.5 1425 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1465 Raleigh 170.4 1446 Little Wabigoon River, bed, 1350; grade 180.0 1356 Taché 180.2 1256 Burnt Stick Creek, bed, 1314; grade 182.5 1547 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 1248 Brulé 190.4 1555 McHugh's Creek, bed, 1207; grade 198.6 1253 Hughes River, bed, 1198; grade 200.2 1241 Wabigoon 202.2 1241 Wabigoon 202.6 1241 Blackwater Creek, bed, 1200; grade 204.5 1241 Thunder Creek, bed, 1205; grade 206.1 1225			
Ignace. 152.3 1487 Osaquan River, bed, 1398; grade 158.7 1426 Buther. 160.5 1428 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1466 Raleigh 170.4 1146 Little Wabigoon River, bed, 1350; grade 180.0 1206 Taché 180.2 1206 Burnt Stick Creek, bed, 1314; grade 182.5 1247 Kirkpatrick Creek, bed, 1320; grade 183.9 1252 Bear Creek, bed, 1333; grade 186.6 1248 Brulé 190.4 1255 McHugh's Creek, bed, 1207; grade 198.6 1253 Hughes River, bed, 1198; grade 200.4 200.8 Hughes River, bed, 1198; grade 202.2 1211 Wabigoon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Osaquan River, bed, 1398; grade 158.7 1420 Butter 160.5 1423 Little Wabigoon River, bed, 1398; grade 165.7 1408 Glencoe River, bed, 1398; grade 167.0 1408 Raleigh 170.4 1140 Little Wabigoon River, bed, 1350; grade 180.0 1206 Taché 180.2 1206 Burnt Stick Creek, bed, 1314; grade 182.5 1347 Kirkpatrick Creek, bed, 1320; grade 183.9 1352 Bear Creek, bed, 1333; grade 196.6 1248 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 1225 Summit, grade 200.4–200.8 1273 Hughes River, bed, 1198; grade 202.2 1241 Wabigoon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Butler 160.5 1425 Little Wabigeon River, bed, 1398; grade 165.7 1408 Glencee River, bed, 1398; grade 167.0 1406 Raleigh 170.4 1446 Little Wabigeon River, bed, 1350; grade 180.0 1356 Taché 180.2 1506 Burnt Stick Creek, bed, 1314; grade 182.5 1347 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 196.6 1348 Brulé 190.4 1357 McHugh's Creek, bed, 1207; grade 198.6 1255 Summit, grade 200.4-200.8 1273 Hughes River, bed, 1198; grade 202.2 1211 Wabigeon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Little Wabigoon River, bed, 1398; grade 165.7 1468 Glencoe River, bed, 1398; grade 167.0 1465 Raleigh 170.4 1146 Little Wabigoon River, bed, 1350; grade 180.0 1256 Taché 189.2 1256 Burnt Stick Creek, bed, 1314; grade 182.5 1257 Kirkpatrick Creek, bed, 1320; grade 183.9 1852 Bear Creek, bed, 1333; grade 186.6 1248 Brulé 190.4 1255 McHugh's Creek, bed, 1207; grade 198.6 1258 Summit, grade 260.4–200.8 1273 Hughes River, bed, 1198; grade 202.2 1241 Wabigoon 202.6 1241 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Glencoe River, bed, 1398; grade 167.0 1466 Raleigh 170.4 1146 Little Wabigoon River, bed, 1350; grade 180.0 1396 Taché 180.2 1506 Burnt Stick Creek, bed, 1314; grade 182.5 1507 Kirkpatrick Creek, bed, 1320; grade 183.9 1652 Bear Creek, bed, 1333; grade 186.6 1348 Brulé 190.4 1555 McHugh's Creek, bed, 1207; grade 198.6 1255 Summit, grade 260.4-200.8 1255 Hughes River, bed, 1198; grade 202.2 1241 Wabigoon 292.6 1241 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Raleigh 170.4 1440 Little Wabigoon River, bed, 1350; grade 180.0 1356 Taché 180.2 1200 Burnt Stick Creek, bed, 1314; grade 182.5 1546 Kirkpatrick Creek, bed, 1320; grade 183.9 1552 Bear Creek, bed, 1333; grade 186.6 1348 Brulé 190.4 1555 McHugh's Creek, bed, 1207; grade 198.6 1255 Summit, grade 200.4-200.8 1255 Hughes River, bed, 1198; grade 202.2 1211 Wabigoon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			
Little Wabigoon River, bed, 1350; grade. 180.0 1356 Taché 180.2 1256 Burnt Stick Creek, bed, 1314; grade 182.5 134 Kirkpatrick Creek, bed, 1320; grade 183.9 135 Bear Creek, bed, 1333; grade 196.6 138 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 127 Hughes River, bed, 1198; grade 202.2 121 Wabigoon 202.6 121 Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 122			
Taché 180.2 1556 Burnt Stick Creek, bed, 1314; grade 182.5 1347 Kirkpatrick Creek, bed, 1320; grade 183.9 1852 Bear Creek, bed, 1333; grade 196.6 1348 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 125 Hughes River, bed, 1198; grade 202.2 121 Wabigoon 202.6 121 Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 125			
Burnt Stick Creek, bed, 1314; grade 182.5 104; Kirkpatrick Creek, bed, 1320; grade 183.9 1052 Bear Creek, bed, 1333; grade 186.6 134 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 125 Hughes River, bed, 1198; grade 202.2 121 Wabigoon 202.6 121 Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 125			
Kirkpatrick Creek, bed, 1320; grade 183.9 1352 Bear Creek, bed, 1333; grade 186.6 1348 Brulé 190.4 155 McHugh's Creek, bed, 1207; grade 198.6 1255 Summit, grade 200.4–200.8 1251 Hughes River, bed, 1198; grade 202.2 1241 Wabigoon 202.6 1241 Blackwater Creek, bed, 1200; grade 204.5 1241 Thunder Creek, bed, 1205; grade 206.1 1225			
Bear Creek, bed, 1333; grade 186.6 138 Brulé 190.4 135 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 260.4-200.8 125 Hughes River, bed, 1198; grade 202.2 121 Wabigoon 292.6 121 Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 125			
Brulé 190.4 155 McHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 125 Hughes River, bed, 1198; grade 202.2 121 Wabigoon 202.6 121 Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 125			
MeHugh's Creek, bed, 1207; grade 198.6 125 Summit, grade 200.4–200.8 125 Hughes River, bed, 1198; grade 202.2 121 Wabigoon 202.6 121 Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 125			1048
Summit, grade 200.4–200.8 12% Hughes River, bed. 1198; grade 202.2 1211 Wabigoon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225			1.35
Summit, grade 200.4–200.8 12% Hughes River, bed. 1198; grade 202.2 1211 Wabigoon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225	McHugh's Creek, bed, 1207; grade	198.6	125
Wabigoon 202.6 1211 Blackwater Creek, bed, 1200; grade 204.5 1211 Thunder Creek, bed, 1205; grade 206.1 1225	Summit, grade	0.4-200.8	1255
Blackwater Creek, bed, 1200; grade 204.5 121 Thunder Creek, bed, 1205; grade 206.1 1225	Hughes River, bed, 1198; grade	202.2	1211
Thunder Creek, bed, 1205; grade 206.1 1225	Wabigoon	202.6	1211
Thunder Creek, bed, 1205; grade 206.1 1225	Blackwater Creek, bed, 1200; grade	204.5	1211
			1225
	Barclay		1251
Summit, cutting 10 feet; grade			

,:-AV.]

Wabig

Shosho Oxdrift Beaver 11 Eagle I Eagle F Summi Vermili Grass C Eagle 1. Gilbert Muskra Summit Farrywe Stewart Summit. grad Outlet of Parrywo sum Ontlet of Mud Lak Feist Lal Turtle La Summit: Summit ! Clare Lal Viaduet I Hawk La Outlet of Trout Lal Beaver (d

Rossland Rat Porta Winnipeg low w grade Lake of th Keewatin

Winnipeg Mink Bay Winnipeg War Eagle Ostersund

Summit, et Lake Bobo

from Feet above rithers. Wabigoon River, bed, 1178; grade	Port Arthur. 215.4	the sea. 1219
Shoshogawae River, bed, 1151; grade. Oxdrift Benyer River, first crossing, bed, 1129;	215.4	1219
Oxdrift	990 0	
Penyer River, first crossing, bed, 1129;		1159
Beaver River, first crossing, bed, 1129;		1162
	grade 225.8	1149
.0 1546 " second crossing, bed, 112	5; grade 226.4	1139
.2 1534 " " third crossing, bed, 1123:	; grade 229.4	1153
Eagle River station	2318	1186
Eagle River, bed, 1148; grade	232.2	1190
.4 Summit, cutting 7 feet; grade	234.9	1278
·2 Vermilion Bay station · · · · · · · · · · · · · · · · · · ·	242.0	1221
.6 1515 Grass Creek, bed, 1183; grade	242.5	1213
.5 Eagle Lake, water about 1182; grade.	246.9	1210
6ilbert	249.8	1217
3.6 Muskrat Lake, water, about 1174; grad	e 251.0	1206
Summit, natural surface and grade		1295
5.2 I515 Parry wood		1292
6.0 lat; Stewart Lake, water, 1303; grade	, and the second	1328
6.6 Summit near Forest Lake, natural		
3.6 1558 grade		1382
24.0 1557 Outlet of Swan Lake, bed, 1332; grade		1362
Parrywood Lake, water, about 136		1002
summit)		1379
Ontlet of Ulverston Lake, bed, 1318;		1364
Mud Lake, water, 1328; grade		1355
18.3 Feist Lake, water, 1326; grade		1347
Turtle Lake, water, 1366; grade		1376
43.7 1150 Summit station, cutting near, 10 feet;		1385
44.8 Summit Lake, water, 1384; grade		1385
51.3 Clare Lake, water, 1284; grade		1295
52.3 1457 Viaduct Lake, water, 1264; grade		
58.7 Hawk Lake station		1282
Hawk Lake station		1289
Office of Narrow Lake, Ded, 1220; gra		1256
100 lake Cleek, bed, 1215, grade.		1248
Beaver (depression of grade near Beave		1186
100 O 100		1128
Rat Portage		1087
Winnipeg River, outlet of the Lake	•	
low water, at same level with the	, , , , , , , , , , , , , , , , , , , ,	
100 c 100 c		1087
Lake of the Woods, mean, 1060; low an		1057-1063
Keewatin		1075
Winnipeg Bay, water, 1043; grade		1062
Mink Bay, water, 1043; grade	302.4	1070
Winning Bay, Water 1043; grade	303.7	1078
War Eagle Rock Lake, water, 1082; g	rade 305.8	1121
Ostersund	308.3	1105
Summit, cutting 33 feet; grade	311.4	1187
209.8 Lake Bobo, water, 1138; grade	312.7	1151
211.5 1267 1267 1267 grader		

Mil. . . . C

	Miles from	Feet above
T 1 T) 1 1 1004 1-	Port Arthur.	the sea.
Lake Deception, water, 1094; grade		1143
Deception		1136
Bear Lake, grade		1192
Summit, at west end of a cut 35 feet deep; grade		1218
Monument Lake, grade		1218
Red Pine Lake, grade		1226
Fellows Lake, water, 1235; grade (eleven feet lowe		
than the lake)		1224
Kalmar		1217
Summit Lake, water, 1252; grade		1255
Kennedy Lake, water, 1245; grade (two feet lowe		
than the lake)		1243
White Fish Lake, water, 1213; grade	323.8	1243
Summit, 30 rods west from the centre of a cut 33 fee		
deep; grade	325.8	1221
Ingolf	. 328.2	1184
Summit, cutting 30 feet; grade		1150
Cross Lake station, water, 1045; grade	. 334.4	[092
Depression, grade	336.2	1053
Telford	. 338.5	1059
Summit, grade, two feet above the natural surface.	. 342.3	1115
For two and a half miles east and one mil		****
west the surface is very smooth, 1105 to 1113	3.	
River Brenton, water, 1041; grade		1050
Rennie		1053
Bog River, water, 996; grade	354.7	1007
water, 993; grade		996
Darwin		971
Westward to the Red River the country is		3711
mostly swamp, bearing alders and tamaracks		
The swamp is underlain by a hard bottom a		
depths varying commonly from 5 to 15 feet		
Bog River, water, 927; grade	364.0	Cube
Whitemouth River, water 877; grade	368.1	935
Whitemouth Whitemouth		900
Beaver Creek, water, 885; grade		907
Shellv		904
		929
Monmouth		879
Bear Creek, water, 820; grade		831
Broken Head River, water, 784; grade		796
Beausejour		814
Tyndall		796
Devil's Creek, water, 770; grade		777
East Selkirk		743
Red River at West Selkirk, two miles west of Eas		
Selkirk, "ice, 1876" [probably two or three fee		
above extreme low water], 712; flood of 1876		
723; flood of 1875, 725; extreme high water	,	
flood of 1826, 732; range, 22 feet	411.0	710-732

PHAM.

The: lea cro Lake Wi appro Cook's Cr (ionor... Bird's Hi Winnipeg Red River in ore 749; 9 Winnipeg b. Mai From With un Winnipeg, Junction of Junction of Junction of Point of be distance

Air Line Ju Colony Cree

Northwest Dry Creek, be Burnside.... Rat Creek, was Bagot Image Creek, McGregor

Austin
Apparently a lof Lake 2

from	Feet above
thur.	the sea.
.1	1143
.4	1136
.2	1192
.7	1218
.3	1218
.2	1226
.7	1224
.4	1217
. 1	1255
.1	1243
8.8	1243
5.8	1221
8.2	1184
8.9	1100
4.4	1092
6.2	1053
8.5	1059
2.3	1115
18.7	1050
19.0	1053
54.7	1007
56.2	596
59.4	971
9	
64.0	935
68.1	900
68 9	907
69.8	904
74.9	929
84.9	879
$87.4 \\ 01.1$	831
	796 814
94.3 - 00.9	796
	777
02.3	743
08.9	(40
11.0	710 -732

APPENDIX II.		124
	Miles from Port Arthur.	Feet above the sea.
The railway at East Selkirk turns southwar	d,	
leaving the line of its original survey, which	eh	
crossed the Red River here.		
lake Winnipeg, mean, 710; low and high water	r,	
approximately		708-713
ook's Creek, water	409.1	728
ionor	415.0	757
Bird's Hill station	422.1	7.9
Winnipeg Junction, Emerson branch	427.8	752
Red River, extreme low water, 723; highest water	er	
in ordinary years, 735-740; high water, 188	32,	
749; grade, Louise bridge	429.0	752
Winnipeg	429.8	757
b. Main line; from Winnipeg to the Rocky Moun	ntains and L	onald.
From profile in the office of R. M. Pratt, engi	neer, Winni	peg.

From profile in the office of R. M. Pratt, engineer, Winnipeg.
With uniform addition of twenty-four feet, as before explained

With uniform addition of twenty-four feet, as b		olained.
M	iles from	heet above
Winnipeg, 1422.8 miles from Montreal	0.0	757
Innetion of Southwestern branch	1.1	760
Junction of Manitoba & Southwestern Railway	1.2	760
Junction of West Selkirk branch	1.5	759
Point of beginning of the original profile (at 0 of		
distances measured thence westward)	1.8	761
Air Line Junction, of Stonewall branch	1.9	761
Colony Creek, water, 169; grade	3.3	776
" water, 772; grade	4.0	780
Junction of \ innipeg & Hudson Bay Railway	4.7	780
Bergen	7.4	784
Resser	15.2	796
Meadows	22.3	793
Marquette	28.9	807
Reaburn	35.2	806
Long Lake, ordinary low and high water, 798-803;		
grade	35.7	804
Poplar Point	40.4	815
High Bluff	48.7	829
Portage la Prairie, junction of the Manitoba &		
Northwestern Railway	56.0	854
Dry Creek, bed, 858; grade	63.4	872
Burnside	63.5	872
Rat Creek, water, 862: grade	65.1	890
Bagot	71.1	935
Image Creek, water, 939; grade	75.6	953
McGregor	77.6	961
Austin	84.5	1005
Apparently a beach ridge (the lower Campbell beach		
of Lake Agassiz), crest, 1066; grade	86.9	1061

· V	liles from Vinnipeg.	Feet above the sea.
Again, apparently a beach ridge (the upper Campbell beach, second ridge), crest, 1081; grade	87.2	1076
Again (the upper Campbell beach, first ridge), crest,		
1087; grade These beach ridges are each about 30 rods wide, with descents of 10 to 20 feet from their crests to their east bases and half as much to the west. A very uneven profile, intersected by numerous ravines, extends from 89.3 to 92.0 miles, in which distance the grade rises from 1124 to 1232 feet.	875	1085
Sydney	92.6	1232
It is again very uneven from 93.7 to 95.9 miles, in which distance the grade ranges from 1234 1251 feet. Here and westward the profile shows frequent		
lakelets, but no names for them are given.		
Malbourne	98.0	1248
Pine Creek water, 1199; grade	99.7	1224
An uneven surface of low dunes extends from 101.1 to 102.7 miles, the grade varying from 1244 to 1257 feet.		
Carberry	105.5	1258
Horman beach (dd) of Lake Agassiz, crest, 1263;		
and a	107.6	1264
Herman beach (d), crest, 1268; grade	108.9	1267
1249).	114.0	1:300
Sawell	114.2	1255
Donglas	121.5	1222
Chater	127.2	1213
Assiniboine River, water, 1161; grade	131.0	1177
Brondon	132.7	1194
Kemnay	140.9	1364
Alexander	148.4	1400
Griswold	157.4	1417

men.]

Flat Cree Oak Lake

Gopher C Virden.. Hargrave Elkhorn . Fleming . Moosomin Red Jacke Wapella . .

Burrows . Whitewood Percival .. Summit, gr Broadview Oakshela .

Grenfell... Summerber Wolseley .. Sintaluta .. Indian Hea Qu'Appelle McLean

Summit, gra Balgonie ... Pilot Butte. Regina, jun Railway Pile of Bones

Grand Coulé Grand Coulée Pense.... Belle Plaine. Pasqua..... Mocse Jaw C.

Moose Jaw ... Boharm Caron.... Mortlach Parkbeg

Summit, grade Secretan (on th chaplin Ernfold Summit, grade Morse

Herbert Summit, grade

s from nipeg.	Feet above the sea.		1070	Miles from Winnipeg.	Feet above the sea.
			Flat ('reek, water, 1376; grade	102.4	1391
7.2	1076	ш	Oak Lake station	104.7	$\frac{1415}{1422}$
			Gopher Creek, water, 1404; grade	100.0	1422
375	1085		Hargrave	100.0	
		ш	Hargrave	100.0	1579 1630
			Elkhorn		1794
			Flening		1884
			Moosomin. Red Jacket.		1917
			Wapella	220.4	1917
			Wapella		1948
			Whitewood		
					1966
92.6	1232		Percival		2038
			Summit, grade		2054
			Broadview		1960
			Oakshola		1952
			Grenfell		1957
			Summerberry		1938
98.0	1248		Wolseley · · · · · · · · · · · · · · · · · · ·		1950
99.7	1224		Sintaluta		1984
			Indian Head		1924
			Qu'Appelle		2134
			McLean		2284
105.5	125	8	Summit, grade		2286
:			Balgonie		2187
107.6	120	64	Pilot Butte		2016
108.9	120	67	Regina, junction of the Regina & Long Lake		
8			Railway		1885
b			Pile of Bones Creek (Wascana River), grade		1861
			Grand Coulée station		1857
3			Grand Coulée (Creek), grade		1842
1			Pense		1881
			Belle Plaine		1902
		- 9	Pasqua		1872
			Mocse Jaw Creek, grade		1761
,			Moose Jaw		1767
114.5	2 1	1255	Boharm		1792
			Caron		1841
1			Mortlach	423.6	1961
2			Parkbeg	432.8	1982
1			Sammit, grade	442.9	2282
121.	.5	1000	Secretan (on the Missouri Coteau)	443.2	2282
127.		1213	naplin	452.0	2202
131		1177	Emfold	461.4	2288
132		1194	Summit, grade	464.2	2374
140	-	1364	Morse		2274
148		1406	Herbert	480.6	2311
157		1417	Summit, grade	485.2	2377
101	. 1		0		

GLACIAL LAKE AGASSIZ IN MANITOBA.

	Miles from Winnipeg.	Feet above
Rush Lake station		the sea. 2301
Summit, grade		2420
Waldec		2357
Aiken's		2401
Swift Current Creek, grade		2415
Swift Current station		2423
Leven		2467
Goose Lake station		2465
Summit, grade		2586
Depression, grade		2542
Summit, grade		2590
Antelope		2556
Gull Lake station		2569
Cypress		2637
Sidewood		2478
Crane Lake station		2518
Summit.grade		2568
Colley		2509
Summit, grade		2561
Maple Creek station	596.7	2495
Maple Creek, grade		2497
Kinearth		2497 2531
Summit, grade		2546
Forres		2428
Walsh		2428
Summit, grade		2430
Irvine		2022
Dunmore, junction of the Northwest Coal &		2493
Navigation Company's Railway		2405
Medicine Hat		
South Saskatchewan River, low and high water		2171
		444.00
2137-2154; grade		2173
	•	2431
Bowell		2582
Summit, grade		2594
Depression at tank, grade		2384
Suffield		2455
Langevin (a summit of grade)		2495
Kininvie		0424
Tilley		2462
Summit, grade		25(r.
Bantry		2471
Tank four miles west of last		2474
Cassils		2517
Southesk		2501
Lathom		2554
Bassano		2589
Summit, grade	764.4	** (**)

Crowfoo Summi Crowfor Cluny ... Gleicher Sammit, Namaka Summit, Strathmo Cheadle. Summit, Langdon . Summit, p Pepression Shepard.. Summit, Bow River Elbow Riv Bow River Calgary... Keith.... Cochrane ... Radnor.... ${\it Morley}\dots.$ Kananaskis Kananaskis The Gap, sta Bow River h water, al Branch of Bo Canmore ... Bow River, w Puthil..... Devil's Head Anthracite... Banff (new st

Castle Mounta Eldon..... Baker's Creek, Lion Creek, wa Laggan.... North branch o

Forty Mile Cr

Cascade.....

Bow River, w

South branch o Bath Creek, was or Kicking

s from nipeg. 9.3

5.4 6.7

14.8

09.7

10.6

19.6 28.9

532.3

533.7

535.5

538.5

546.3554.8

565.4

575.5

583.9

585.9

589.2

596.7

597.2

. 605.9

608.9

. 615.5

. 627.9

. 636.4

638.3

. 652.8 . 660.3

660.6

. 667.3 . 675.1

. 675.7 . 682.6 . 686.6 . 695.2

.. 704.1 . 713.3

.. 719.3 .. 723.1 .. 727.1

.. 733.1

...740.7

.. 748.9 .. 757.5

.. 764.4

Feet above the sea. 2301 2420

2357 2401

2415

2423

2467

2465 2586

2542

2590

2556

2562

2637 2478

2518

2568

25(0)

2561

2495

2497

2531

2546

2424

2430

2500

2493

24052171 2173

2431

2582 2594

23% 2455 2495

2429 2462

		Miles from Winnipeg.	Feet above
	rowfoot		2698
	Summit a half mile east of tank	. 768.4	2739
	rowfoot Creek, grade	. 770.1	2689
	luny	. 776.5	2850
	leichen		2952
	Simmit, grade		2997
	Samaka		2971
	Summit, near tank		3038
	Strathmore	. 801.0	3032
	headle	. 809.4	3189
	summit, grade	. 815.0	3306
	Langdon		3292
	Summit, grade · · · · · · · · · · · · · · · · · · ·		3373
	Depression, grade	, 828.2	3334
	shepard		* 3370
	summit, grade		3409
	Bow River, grade		3377
	Elbow River, water, 3394; grade		3411
	Bow River at the mouth of Elbow River, water		3390
	Calgary		3421
	Keith		3547
	(ochrane		3743
	Radnor		3876
	Morley		4061
	Kananaskis River, bed		4149
	Kananaskis		4214
	The (iap, station		4225
	Bow River here, at point of issue from the mountain		
05	water, about		4215
	Branch of Bow River, water		4220
	Canmore		4278
173	Bow River, water		4359
431	Puthil		4380
582	Devil's Head Creek, water		4436
594	Anthracite		4484
2384	Banff (new station)		4515
2455	Forty Mile Creek, water		4505 4531
2495	Bow River, water		
5454	Castle Mountain station		4586 4653
2462	Eldon		4804
250r	Baker's Creek, water.		4852
2471	Lion Creek, water, 4949; grade		4970
2474	Lagran		5029
2517	North branch of Bow River, water		5020
2501	South branch of Bow River, water		5049
253/11	Bath Creek, water		5263
2589	Summit of grade crossing Rocky Mountains, Wap		0200
-1	or Kicking Horse pass		5323
	Parano Permi		0020

Miles from Winnipeg. Stephen 962.7	Feet above the sea.
Summit Lake, water 962.7	5313 530s
Hector	5197
Kicking Horse Lake, water	5190
Kicking Horse River, first crossing, water 966.2	5184
Mount Stephen tunnel, grade 970.4	4335
Field	4058
Muskeg summit, grade 975.7	4164
Ottertail Creek, water, 3746; grade 978.4	3856
Ottertail	3689
Kicking Horse River, water 981.4	3665
Leanchoil 986,4	3570
Summit grade 988.6	3669
Kicking Horse River, fourth crossing, water 992.7	3287
Palliser 994.2	3077
Kicking Horse River, sixth crossing, water, 2666;	
grade1003.5	2682
Golden	200 m
Columbia River here, at the mouth of Kicking	
Horse River, water1006.7	1000
Arm of Columbia River, water1008.7	2538
Moberly House	-0001 -0001 -0001
Blueberry Creek, water1016.7	2544
Donald1023.6	2565
Columbia River, first crossing, grade 1024.4	2544

c. Main line through British Columbia, from Donald to Vancouver,

From H. Abbott, Superintendent of the Pacific Division, Vancouver, w figures, referred to the level of the Pacific Ocean, are given without change the first column of these elevations, showing at Donald a discrepancy of 30 f above the preceding series from Winnipeg, Lake Superior, and the Atlans In the second column these figures are revised by subtraction of 39 feeting the east end of the series for agreement at Donald; by comparison with a pm from Donald to Sicamous, supplied by P. A. Peterson, engineer, Montreal, while indicates that this correction should be reduced to 30 feet at Glacier House onward, and to 20 feet at Twin Butte and onward; and by comparison w elevations supplied by Dr. G. M. Dawson, copied from profiles in the office Collingwood Schreiber, engineer of government railways, Ottawa, which seem require the continuance of this subtraction of 20 feet west to Notch Hills Shuswap, beyond which they indicate that the elevations received from Abbott are probably correct. This line, however, needs verification by level from Donald to Lytton, about 300 miles, within which distance the discrepa of 39 feet at Donald can probably be eliminated. At Lytton, and through remaining distance of about 150 miles to Vancouver, these elevations agree those published by Dr. Dawson in advance sheets of the second editi Macfarlane's American Geological Railway Guide, and with the blue condensed profile prepared in the engineers' office of this railway, Montreal

-nus-7

Donald. Beaver . . Six Mile Bear Cre Rogers P. Summit g Selkin Glacier H Ross Peak Illecillewa Albert Ca Twin Butt Revelstoke Colum Summit gr Gold r. Clanwillian Griffin Lak Craigellachi Sicamous Shuswa station. Salmon Ari Tappen Sidi: Notch Hill 8: Shuswap Duck's Kamloops... Tranquille ... Cherry Creek Savona's ... Penny's Asheroft patsum.... Spence's Brid

Drynock

Lytton.....

Keefer's

North Bend..

Spuzzum

Норе....

Ruby Creek st

Agassiz

Harrison....

Nicomen....

from	Feet above	Miles from Winnipeg,	Feet above	Feet above
peg.	the sea. 5313	winnipeg.	(Abbott.)	(Revised.)
.7	5308	Donald	2604	2565
.0	5197	Beaver	2453	2414
.0	5180	Six Mile Creek station	2633	2594
.2	5184	Bear Creek station1050.0	3680	3641
.4	4335	Rogers Pass station	4222	4183
3.2	4()5×	Summit grade in Rogers Pass, crossing the		
5.7	4164	Selkirk Mountains 1056.5	4366	4327
3.4	1856	Glacier House station	4102	4072
).2	3689	Ross Peak Siding	3471	3441
.4	3665	Illecillewaet	2740	2710
3.4	3570	Albert Canyon station1081.0	2244	2214
8.6	3669	Twin Butte station1091.0	1918	1898
$\frac{8.0}{2.7}$	3287	Revelstoke (at the second crossing of the		
4.2	3275	('olumbia River)1103.0	1515	1495
14.2	0=10	Summit grade in Eagle Pass, crossing the		
us E	2682	Gold range	1848	1828
3.5	2570	(lanwilliam	1827	1807
06.7	m+1211	Griffin Lake station	1537	1517
	-0.00	Craigellachie	1259	1239
06.7	2538	Signature bridge crossing narrows of	1201	12017
08.7	2007	Shuswap lake, 1173 (1153); Sicamous		
13.4	2544	station	1171	1151
16.7	2565	Salmon Arm	1175	1155
23.6	2544	Tappen Siding1173.5	1168	1148
)24.4	2011	Notch Hill station (Shuswap summit)1183.0	1708	1688
		Shuswap	1173	1153
d to Ve	ancourer.	Duck's	1150	1100
- 37	ancouver, who	Kamloops1231.5	1153	
on, v	ithout changei	Tranquille	1134	
ven w	repancy of 39 h	Cherry Creek station	1134	
disci	nd the Atlanti	Savona's	1154	• • • •
nor, a	on of 39 feet fri	Penny's	1252	
tractio	son with a post	Asheroft	996	• • • •
mpari	, Montreal, whi	Spatsum	854	• • • •
gineer	Glacier House	Spence's Bridge station	768	
et at	comparison w	brynock	752	• • • •
ind by	es in the office	Lytton		
proni	wa, which seem	Cisco	687	
, Otta	to Notch Hills	Keefer's	558	
west	received from		555	
tions	received from	North Bend	487	
verit	leation by level	Spazzum	394	
Cistan	ce the discrepa	Yale	217	****
Lytto	n, and through	Норе1393.5	208	
ese ele	evations agree	Ruby Creek station 1401.5	94	* * * *
of the	e second editi	\Agassiz1411.5	52	• • • •
and v	with the bluep ilway, Montrea	Harrison	38	
			23	

Α. es from

Miles from Winnipeg.	Feet above the sea. (Abbott.)	Feet above the sea. (Revised:
Mission1439.5	33	t tar
Wharnock1449.5	14	
Hammond1457.5	19	
Port Moody1469.5	5	
Hastings1478.0	22	
Vancouver, 2004.8 miles from Montreal1482.0	3	,

d. Emerson Branch.

From Collingwood Schreiber, engineer of government railways, Ottawa. It agrees with the Saint Paul, Minneapolis & Manitoba Railway on the international boundary.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Red River, grade on Louise bridge	0.8	759
Winnipeg Junction (of this branch with the main		
line)	2.0	100
Saint Boniface, 429.6 miles from Port Arthur	3.0	751
River Seine, high water	10.5	760
Saint Norbert	12.0	767
Niverville	23.5	774
Rat River, low water, 752; high water	30.0	763
Otterburne	30.6	779
Dufrost	39.0	791
Arnaud	47.0	794
Roseau River, low water, 761; high water, 1880	54.5	779
Dominion City	55.0	7*5
Joe River, low water, 756; extreme high water	62.6	785
Emerson, 391.1 miles from Saint Paul	65.0	790
Grade on the international boundary, connection		
with the St. P., M. & M. Railway	65.1	790

e. Southwestern Branch.

From R. M. Pratt, engineer, Winnipeg; and west of Manitou in part fm profile in the office of P. A. Peterson, engineer, Montreal.

The profile requires an addition of twenty-four feet, which is made here agrees near Gretna and at Emerson with lines of the Saint Paul, Minneapola Manitoba Railway on the international boundary, and at Thornhill where levelling from Park River, North Dakota, in the survey of the beaches of Li Agassiz.

OSIIA	Miles from	Feet ai
	Winnipeg.	thesa
Winnipeg, 1422.8 miles from Montreal	0.0	707
Junction of this branch with main line	1.1	760
Saint James	3.6	764
Assiniboine River, ordinary low and high water	3.7	736-754
Assimbolite 101461, ordinary for and ingli water	0.1	100

PARE .

La Salle wate La Salle Seratchin wate The

4, in Morris ... Rosenfeld On the Gretna ... Grade on

with a Railwa On the Eme Crossing the Marais Riv West Lynn Red River, Emerson...

Thornhill....
summit, gra
Parlingford.
summit, gra
Manitou....
In the d
Pembi

On the Morden . . .

Very ir deep at La Riviere . . Pembina Riv Ascondin

is brok where The wid Pilot Mound. Summit, grad

Crystal City... Crystal Creek, Summit, natur Clearwater, w

1426; grad

	_
•	
	Feet above
above	the sea.
bott.)	(Revised.)
33	
14	
19	
5	
22	
3	
railways	, Ottawa
oba Rai	lway on the
iles from	Feet above
innipeg.	the sea.
0.0	757
0.8	752
2.0	752
3.0	754
10.5	760
12.0	767
23.5	774
30.0	763
30.6	779
39.0	791
47.0	794
54.5	779
55.0	745
62.6	785
65.0	790
65.1	790
	to and too
Man	itou in part im
er, Mo	ntreal.
which	is made here. I
int Pa	ul, Minneapola
and a	t Thornhill wi
of th	e beaches of Li
	T at
	from Feet at 1
	ipeg. the scale
	.1 766
	1.6 764
	3.7 736-734
_	

3		
	Miles from Winnipeg.	Feet above
a Salle (or Stinking) River, ordinary low and high		the seas
water		737-750
La Salle station		770
water	42.0	744-770
The upper part of this stream, above the marshes in which it is lost in T. 7, Rs. 2, 3 and 4, is called Boyne River (R. aux Hes du Bois)	l	
Morris		772
Rosenfeld, junction of lines to the south and west On the line south from Rosenfeld:	. 56.2	796
Gretna	n	829
Railway	. 70.4	830
On the line (abandoned) from Rosenfeld t Emerson:	0	
Crossing the first initial meridian, grade	. 62.1	794
Marais River (R. aux Marais), bed		781
West Lynne		790
Red River, low and high water		750-787
Emerson		790
On the line west from Rosenfeld:		
Morden	. 80.6	978
Thornhill	87.9	1314
Summit, grade	. 94.4	1588
Parlingford	. 95.9	1560
summit, grade	. 99.4	1618
Maniton	102.4	1586
In the descent from the top of the bluff of th	10	
Pembina River valley at 106 miles (grad-	θ,	
1552) to its bottom at 112 miles, the profile	is	
very irregular, with frequent cuts 10 to 50 fe deep and fills of 10 to 30 feet.	et	
La Riviere	112.5	1304
Pembina River, water, 1287; grade		1304
is broken by many ravines to 119 mile	8,	
where grade at the top of the bluff is 154		
The width of this valley is one to two mile		
Pilot Mound		1549
Summit, grade		1555
Crystal City		1513
(rystal Creek, water, 1474; grade		1500
Summit, natural surface and grade	k,	1 519
1426; grade at station	134.1	1498

Miles from Winnipeg	
Smoothly undulating contour reaches from 137	
to 141 miles, with grades from 1515 to 1532;	
also between 141 and 147 miles, with grades	
from 1525 to 1535 feet.	
Cartwright 144.9	1593
Badger Creek, water, 1476; grade 147.6	1500
Moderately undulating surface extends thence	
to 156 miles, the highest grades being 1535 to	
1551 feet.	
Holmfield 155.4	1551
Long River (White Mud River), water, 1541; grade 155.7	1551
Thence the line rises gradually westward to	
169.4 miles, where the natural surface and	
grade are 1649 feet.	
Killarney 164.1	1625
Little Pembina station	1649
Pembina River, water, 1605; grade 170.3	1645
The valley here is only 40 feet deep and about	
40 rods wide.	
Lake, water, 1636; grade	1641
Lake, water, 1645; grade	1645
Summit, level grade	· 7 1690
Boissevain 182.7	1683
Whitewater Lake, low and high water 192.7	1632-1637
Deloraine 202.7	1644
The last twenty-five miles of this line lie near	
the northern base of Turtle Mountain.	

f. Manitoba & Southwestern Railway.

[Operated by the Canadian Pacific Railway Company.]

From R. M. Pratt, engineer, Winnipeg, and west of Elm Creek in partical profile in the office of P. A. Peterson, engineer, Montreal.

With uniform addition of twenty-four feet.

	Miles from	Feet along
	Winnipeg.	the .c.
Winnipeg	0.0	757
Junction with Canadian Pacific Railway		"Fall
Colony Creek, bed	2.8	604
Sturgeon Creek, low water	7.5	776
Assiniboine River, low and high water	14.0	754-764
Headingly	14.2	77
La Salle River, low and high water	26.8	766-771
Starbuck	27.2	781
Elm Creek station, junction of Carman branch On the Carman branch:	45.0	\$19
Maryland (on the Burnside beach of Lake Agassiz)	47.5	814
Barnsley (end of track)		854

entile.

End of Boyne 1 wat On Burnsid The

Slough, Slough, Slough, Boyne R

The an Norcross Herman The can

Summit, and Little Boy Treherne Boyne Ri Herman I

Summit, 1 the hi Holland... Cypress Ri Glenboro (

Summit in Divide bet Lang's that flo Prairie wes Souris Rive

The following from Winnipeg four feet, like th

47.5

51.0

814

854

		'limes,		
on from	Feat above		Miles from Winnipeg.	Feet above
innipeg.	the sea,	End of grade, one mile north of Carman	56.0	861
		Boyne River (R. aux Iles du Bois), low and high		301
		water		842-854
		On the main line west from Elm Creek junction		010
44.9	1500	Burnside beach of Lake Agassiz, crest, 845; grade		841
47.6	1509	The descent from the crest eastward is ten feet		
41.0	\$100.0	in 25 rods, and westward seven feet in an equal distance.		
	1	Slough, water, 965; grade	57.8	967
55.4	1551	slough, water, 1016; grade	63.0	1018
55.7	1551	Slough, water, 1043; grade	66.0	1045
		Boyne River, low water, 1034; grade	68.9	1047
		Norcross beach b of Lake Agassiz, crest, 1167; grade	75.2	1162
164.1	1625	The descent from the crest eastward is 15 feet and westward 10 feet.		
169.7	1649	Norcross beach a, crost, 1195; grade	75.7	1191
170.3	1645	Herman beach dd, crest, 1211; grade		1206
110.0	*****	The descent from the crest eastward is 15 feet and westward 7 feet.	,	•
171.7	1641	Summit, on the Herman beach d, natural surface	,	
172.2	1648	and grade		1217
.1-181	7 1690	Little Boyne River, low water, 1169; grade	77.3	1209
182.7	1683	Treherne	77.6	1212
192.7	1632-1637	Boyne River, low water, 1166; grade	78.4	1222
202.7	1644	Herman beach bb, crest, 1252; grade	80.6	1247
		The descent from the crest both to the east and west is about ten feet.		
		Summit, natural surface and grade the same, being	g	
ay.		the highest grade on this profile	. 84.8	1248
		Holland	85.9	1237
Compa	my.]	Cypress River station	95.0	1232
Elm Cre	ek in part from	Cypress River, low water	95.7	1214
al.		Glenboro (end of track, 1886)	. 105.0	1231
		Summit in sec. 4, T. 6, R. 16		1489
Miles fr	om Feet about	Divide between Souris River and Pelican Lake, it	n	
Winnip		Lang's Valley (the channel of a glacial rive		
. 0.0	101	that flowed southeast to the Pembina River) .		1364
. 1.2	710	Prairie west of Lang's Valley		1524
. 2.8	7.15	Souris River at Souris City		1164
. 7.5	, vis	" at Milford		1114
. 14.0	754-764			
. 14.2	771	The following branches of the Canadian Pacific Rail	way, runn	ing northwa
. 26.8	766-771	from Winnipeg on the west side of the Red River, recei		
27.9	781	four feet, like the main line from Winnipeg west :-		
45.0	514	, and the time thou training wear !-		

From profile in the office of P. A. Peterson, engineer, Montreal.

	Miles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Junction with main line	1.5	759
This branch is very nearly level, ranging from	a	
760 to 750 feet, between Winnipeg and Lowe	r	
Fort Garry (also called the "Stone Fort").		
Lower Fort Garry	19.5	754
West Selkirk	23.5	736
End of the "river track"	-24.1	724
Red River, ordinary stages of low and high water.	24.1	712-725

h. Stonewall Branch.

From R. M. Pratt, engineer, Winnipeg.

Miles from Winnipeg.	Feet above the sea.
Winnipeg 0.0	7.57
Air Line Junction, with main line 1.9	761
Stony Mountain station 13.3	773
Stonewall 19.8	510

WINNIPEG & HUDSON BAY RAILWAY.

From Collingwood Schreiber, engineer of government railways, Ottawa.

With addition of twenty-four feet, as before explained.

	liles from Winnipeg.	Feet above the sea.
Winnipeg	0.0	757
Junction with the Canadian Pacific Railway	4.7	780
Burnside beach of Lake Lassiz about three miles		
south of Shoal Lake, crest and grade the same.	31.0	860
Lowest natural surface crossed by the railway beside		
Shoal Lake, 852; grade	38.2	855
Shoal Lake, five to fifteen feet deep, surface at		
ordinary low stage, 850; low and high water		849-853

MANITOBA & NORTHWESTERN RAILWAY.

From profiles in the office of George H. Webster, engineer, Portage la Prairie.

These profiles are referred to the Canadian Pacific Railway station at Portage la Prairie, which is called 100 feet. The original figures accordingly receive here a uniform addition of 754 feet to refer them to mean sea level.

κĄV.

Portage stati mile Portage Rail Channel into grade Macdona Westbour White M Burnside grade Woodside White Mu Summit, g Depression Gladstone grade Verge of grade Gladstone,

916; g Depres begin Emerado b 929, wi the cre Depres Third Blan This b

White Muc

Gopher Cre Secondary

from Midway... Second Blan This de ridge wide, depre

First or u nearly grade

Depression,

, Montreal. s from nipeg.

0.0

1.5

 $9.5 \\ 23.5$

24.1 24.1

les from

innipeg.

0.0

1.9 13.3

19.8

innipeg.

0.0

4.7 31.0

38.2

railways, Ottawa. xplained. les from

Feet above the sea.

757

759

754736

724 712 - 725

Feet above

the sea.

757

761

773

810

Feet above the sea.

757

780

860 855

849-853

gineer, Portage

ay station at Portage s accordingly receive sea level.

a. Main line.		
		Feet above
		ie. the sea.
Portage la Prairie, Canadian Pacific Railway station, 1478.8 miles west from Montreal, 50		
miles west from Winnipeg		854
Portage la Prairie, Manitoba & Northwestern	0.0	004
Railway station		856
Channel by which the Assinibo'ne River overflowed		3,10
into Lake Manitoba, May 3-15, 1882, bed, 850		
grade		859
Macdonald		837
Westbourne		831
White Mud River, first crossing, bed, 812; grade		831
Burnside beach of Lake Agassiz, crest, 860-862		001
grade at switch of spur track to gravel pit		860
Woodside		858
White Mud River, second crossing, bed, 849; grade		859
summit, grade (one foot above natural surface)		878
Depression, filling 3 feet; grade		876
Gladstone beach, natural surface at crest, 878		
grade		880
Verge of plain of Gladstone, natural surface, 882		
grade		884
(fladstone, section house and tank, grade		884
" passenger station		883
White Mud River, third crossing, bed, 871; grade.		889
Gopher Creek, bed, 876; grade	. 36.5	888
Secondary Emerado beach, forty rods wide, cres	t,	
916; grade		917
Depression west of this, 914, marking th	Θ	
beginning of a more rapid ascent westward.		
Emerado beach, about thirty rods wide, crest, 927	-	
929, wind-blown in hollows one to two feet below	W	
the crest	. 39.9	927-9
Depression west of this, 925.		
Third Blanchard beach, crest and grade alike		969
This beach ridge is thirty rods wide, wit	h	
descent of five feet both to the east and wes	st	
from its crest.		
Midway		975
Second Blanchard beach, crest, 979; grade4		980
This deposit is almost tlat, not having the usua		
ridged form. It is nearly a quarter of a mi		
wide, and is bordered on the west by	8	
depression of two feet, to 977.		
First or upper Blanchard beach, another tra-		
nearly like the last, natural surface, 994		
grade 45		995
Depression, natural surface, 991; grade	45.5	993

Lower McCauleyville beach, crest and grade alike. 46.4 Depression west of this, 1014. Middle McCauleyville beach, crest, 1029; grade. 47.0 Descent of three and five feet, respectively, to the west and east from the crest. Stream, bed, 1018; grade. 47.1 Upper McCauleyville beach, crest, 1039; grade. 47.6 Descent cf wr and six feet, respectively, to the west and at from the crest. Lower Campbell beach, crest, 1061; grade. 48.2 This beach ridge is twenty rods wide, with descent of eight feet east and five feet west. Slight beach mark, natural surface. 48.6 Beginning of nearly level grade on the east margin of the Arden beach ridge (two feet above the natural surface) 48.7 Arden. 51.6 Upper Campbell beach ridge, excavated for ballast, crest, 1089; grade. 51.8 Snake Creek, bed, 1061; grade. 52.0 Lower Tintah beach ridge, crest and grade alike. 55.4 This has a width of about thirty-five rods, with a descent of four feet to the east and three feet to the west. Beach ridge associated with the preceding, crest, 1115; grade. 55.7 Dune crossed on steep grade, crest, 1133; grade. 56.9 Depression west of this, 1131. Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 11522, and 1154 feet. Level grade (0 to 7 feet above the natural surface) 57.8 This has a descent of eleven feet in fifty rods east, and three feet in six rods west. Nearly level natural surface, 1174-1172; grade. 58.9 This has a descent of five feet to the east and three feet to the west.	Portas	iles from re la Prairie	· · · · · · · · · · · · · · · · · · ·
Depression west of this, 1014. Middle McCauleyville beach, crest, 1029; grade	Level grade (½ to 2 feet above the natural surface).45.7		1004
Descent of three and five feet, respectively, to the west and east from the crest. Stream, bed, 1018; grade	Depression west of this, 1014.		1016
the west and east from the crest. Stream, bed, 1018; grade		47.0	1025
Upper McCauley ville beach, crest, 1039; grade	the west and east from the crest.		
Upper McCauley ville beach, crest, 1039; grade		47.1	1027
Descent c' mr and six feet, respectively, to the west and a st from the crest. Lower Campbell beach, crest, 1061; grade		47.6	1035
This beach ridge is twenty rods wide, with descent of eight feet east and five feet west. Slight beach mark, natural surface	west and c. st from the crest.		
This beach ridge is twenty rods wide, with descent of eight feet east and five feet west. Slight beach mark, natural surface	Lower Campbell beach, crest, 1061; grade	48.2	1056
descent of eight feet east and five feet west. Slight beach mark, natural surface			
Slight beach mark, natural surface			
Beginning of nearly level grade on the east margin of the Arden beach ridge (two feet above the natural surface)		48.6	1070
of the Arden beach ridge (two feet above the natural surface)			*
Natural surface			
Arden		48.7	1079
Upper Campbell beach ridge, excavated for ballast, crest, 1089; grade			1076
crest, 1089; grade		04.0	*******
Snake Creek, bed, 1031; grade		51.8	1084
Lower Tintah beach ridge, crest and grade alike 55.4 This has a width of about thirty-five rods, with a descent of four feet to the east and three feet to the west. Beach ridge associated with the preceding, crest, 1115; grade 55.7 Dune crossed on steep grade, crest, 1133; grade 56.9 Depression west of this, 1131. Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 1152}, and 1154 feet. Level grade (0 to 7 feet above the natural surface) 57.3-57.7 Upper Tintah beach, crest, 1158; grade 57.8 This has a descent of eleven feet in fifty rods east, and three feet in six rods west. Nearly level natural surface, 1174-1172; grade 58.9 This has a descent of five feet to the east and three feet to the west. Ridge of dune sand, crest, 1179; grade 59.3 This likewise has a descent of five feet to the east and three feet to the west. Dunes at the level of the Lower Norcross beach occur			1079
This has a width of about thirty-five rods, with a descent of four feet to the east and three feet to the west. Beach ridge associated with the preceding, crest, 1115; grade	. , ,		1111
a descent of four feet to the east and three feet to the west. Beach ridge associated with the preceding, crest, 1115; grade		00+1	1111
to the west. Beach ridge associated with the preceding, crest, 1115; grade			
Beach ridge associated with the preceding, crest, 1115; grade			
Dune crossed on steep grade, crest, 1133; grade			
Dune crossed on steep grade, crest, 1133; grade 56.9 Depression west of this, 1131. Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 1152½, and 1154 feet. Level grade (0 to 7 feet above the natural surface)		55.7	111.
Depression west of this, 1131. Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 1152½, and 1154 feet. Level grade (0 to 7 feet above the natural sur- face)			1116
Dunes three to five feet high occur at 57.15, 57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 1152½, and 1154 feet. Level grade (0 to 7 feet above the natural sur- face)		90.9	1134
57.2, and 57.3 miles, with crest and grade alike in each, respectively 1150, 1152\frac{1}{2}, and 1154 feet. Level grade (0 to 7 feet above the natural surface)			
alike in each, respectively 1150, 1152½, and 1154 feet. Level grade (0 to 7 feet above the natural sur- face)			
Level grade (0 to 7 feet above the natural surface)	,		
Level grade (0 to 7 feet above the natural surface)			
face)			
Upper Tintah beach, crest, 1158; grade		2.7.7	11-1
This has a descent of eleven feet in fifty rods east, and three feet in six rods west. Nearly level natural surface, 1174-1172; grade58.1-58.8 Ridge of dune sand, crest, 1177; grade58.9 This has a descent of five feet to the east and three feet to the west. Ridge of dune sand, crest, 1179; grade59.3 This likewise has a descent of five feet to the east and three feet to the west. Dunes at the level of the Lower Norcross beach occur			1154
east, and three feet in six rods west. Nearly level natural surface, 1174-1172; grade58.1-58.8 Ridge of dune sand, crest, 1177; grade58.9 This has a descent of five feet to the east and three feet to the west. Ridge of dune sand, crest, 1179; grade59.3 This likewise has a descent of five feet to the east and three feet to the west. Dunes at the level of the Lower Norcross beach occur			1157
Nearly level natural surface, 1174-1172; grade 58.1-58.8 1174-11 Ridge of dune sand, crest, 1177; grade 58.9 11 This has a descent of five feet to the east and three feet to the west. Ridge of dune sand, crest, 1179; grade 59.3 11 This likewise has a descent of five feet to the east and three feet to the west. Dunes at the level of the Lower Norcross beach occur			
Ridge of dune sand, crest, 1177; grade			
This has a descent of five feet to the east and three feet to the west. Ridge of dune sand, crest, 1179; grade			1174-1177
three feet to the west. Ridge of dune sand, crest, 1179; grade		58.9	1178
Ridge of dune sand, crest, 1179; grade			
This likewise has a descent of five feet to the east and three feet to the west. Dunes at the level of the Lower Norcross beach occur			
east and three feet to the west. Dunes at the level of the Lower Norcross beach occur			1180
Dunes at the level of the Lower Norcross beach occur			
at 60.1, 60.2, 60.25 and 60.3 miles, with their	Dunes at the level of the Lower Norcross beach occur		
	at 60.1, 60.2, 60.25 and 60.3 miles, with their		
crests successively at 1192, 11921, 11921, and	crests successively at 1192, 11921, 11921, and		

.:HAM-]

119 four

wos
her
Fro
to
w
ra
in
le
Neepawa
Upper N
1225,
The
on
Eroded
grade
Herman
This

of t by Herman l This: in leng and Stony Cree Bridge Cree Summit go

des from

Little Sask Minnedose Summit, gr Depression Summit, g Basswood Outlet from Summit, hi Newdale

Grade and Grade and Strathelair Salt I ake, Summit, cu Shoal Lake

Shoal Lake Oak River, es from Feet above la Prairie. the sea. 1004 46.146.41016 47.0 1025 47.1 1027 47.61035 48.2 1056 48.6 1070 1079 48.7 1086 51.6 51.8 1084 52.01079 1111 55.4 55.7 1116 1134 56.9 3-57.7 1154 1157 57.8 1174-1177 -58.8 1178 58.9

1180

59.3

Miles from Feet above Portage la Prairie. the sea. 11934 feet. The intervening hollows are two, four, and five feet deep in order from east to west, i.e. at 1190, 11881, and 11871 feet. Grade 1193 From the dunes at 58.9 miles and 59.3 miles to 60.5 miles the surface is wind-blown sand with hollows two to four feet deep. The railway bed, formed of this sand, is somewhat insecure, because of its liability to be channelled by the wind. Neepawa 61.0 1206 Upper Norcross beach, crests successively 12231, 1227-1232 The descent westward from each crest is only one foot. Eroded escarpment, base, 1225; crest, 1240; 1232-1239 Herman beach bb, crest, 1304; grade...... 64.0 1305 This ridge has a width of forty rods, with descent of seven feet both to the east and west from its crest. It is found to consist of sand and gravel suitable for ballast, nearly like that of the Arden ridge, and has been purchased by the railway company for this use. Herman beach b, crest, 1323; grade..... 1320 This ridge descends seven feet from crest to base in tifteen rods, the amount of descent and length of slope being nearly alike on the east and west. Stony Creek, bed, 1359; grade.... 66.31373 Bridge Creek station.... 1600 Summit grade (two feet above natural surface)..... 1798 Little Saskatchewan River, bed, 1654; grade 1669 Minnedosa, junction of Rapid City branch.... 1670 Summit, grade (two feet above natural surface)..... 1928 Depression, filling eight feet; grade 1906 Summit, grade (three feet above natural surface)... 87.0 1956 Basswood 1949 Outlet from Basswood Lake, bed, 1932; grade 88.6 1950 1983 Summit, highest grade on this railway Newdale 96.8 1975 Grade and natural surface...... 100.0 1972 1950 Scathelair 106.1 1901 Salt I ake, bed, 1855; water, 1860; grade.......... 108.3 1867 1879 Summit, cutting four feet; grade............................. 109.0 1812 0ak River, bed, 1791; water, 1794; grade........... 115.0 1811

,

M	· Inom	
M Porta		Feet ab., e
Shoal Lake, about a third of a mile south; water,		riic sea.
approximately	115.0	1793
Summit, cutting two feet; grade	117.0	1830
Kelloe	123.2	1814
Solsgirth	129.8	1789
Grade (eight feet above the natural surface)		1697
Ravine, bottom, 1596; grade		1648
Birdtail Creek, bed, 1538; water, 1540; grade		1558
Summit, grade (one foot above the natural surface).		1704
Birtle		1700
Summit, cutting one foot; grade	138.0	1706
Stony Creek, bed, 1683; grade	139.0	1701
Summit, grade (one foot above the natural surface).		1747
Foxwarren		1742
Summit, grade		1772
Silver Creek, bed, 1631; water, 1632; grade		1704
Binscarth, junction of Shell River branch	154.9	1713
Two miles northwest of Binscarth, natural surface		
and grade	157.0	1654
Three miles farther northwest, natural surface,		
1515; grade		1521
Johnson's Creek, bed, 1350; grade	161.8	1468
Old bed of the Assiniboine River, bed, 1317; stagnant		
water, 1319; grade		134.
Assiniboine River, bed, 1309; water, 1314; grade	162.9	1342
One mile northwest of Assiniboine River, natural		
surface, 1405; grade	164.0	1468
Two miles farther northwest, natural surface and		
grade		1533
Harrowby		1593
Grade and natural surface		1638
Langenburg	180.1	1681
b. Rapid City Branch (Saskatchewan & Western	n Railway).	
	Miles from ge la Prairie	Feet above
Minnedosa	78.5	the sea, 1670
Little Saskatchewan River, first crossing, bed, 1643;		.0111
water, 1645; grade	80.2	1658
Riverdale	87.1	1636
Little Saskatchewan River, second crossing, bed,		10,00
1569; water, 1570; grade		1579
Rapid City A survey from Rapid City westward supplies the following:	93.9	1579
Surface, S. E. 1 of sec. 19, T. 13, R. 20	101 5	1701
" W. ½ of sec. 16, T. 13, R. 20		1701
₩ - 7 Of Sec. 10, 1, 15, R. 21	109.0	1734

Oak Riv pose Surface R. 25 Surface, S

CHAM.

Binscarth Four mile surfac Four mile natur Russell...

d. Line su

Red Deer ... Surface ... Big Cut A: Surface ...

Surface....
Crescent an line, ap Surface...
Surface....
Surface....
Ravine, both

Surface, end This line end meridian, betwee the south, and a

Summit ...

Line surveyed

Armstrong's
"
Yorkton ...
Mill Creek
bed

Surface.....

iles from

80.2

87.1

92.493.9

101.5

05.5

Feet above te la Prairie. the sea.

> 1658 1636

1579

1579

1701

1734

•	1	, -	
from	Feet ab se	Miles from Portage la Prairie.	Feet above
Prairie.	the sea.	Oak River, sec. 23, T. 13, R. 22, water, 1668; pro-	tne sea.
	the sear	posed grade	1703
.0	1793	Surface on line between secs. 28 and 33, T. 14,	1700
.0	1830	R. 25 132.0	1688
.2	1814	Surface, S. W. 1 of sec. 6, T. 15, R. 25. 135.5	1623
.8	1789	Surface, 5. 11. 4 of Sec. 0, 1. 10, 10. 20. 159.0	1020
.0	1697	61 21 02 0 1	
.8	1648	c. Shell River Branch.	
.5	1558	Binscarth	1713
.0	1704	Four miles north of Binscarth, grade and natural	
.6	1703	surface	1791
8.0	1706	Four miles farther north, grade (three feet above	
0.0	1701	natural surface)	1797
.0	1747	Russell	1830
5.2	1742	· ·	
0.0	1772	d. Line surveyed west from Langenburg to the south side of the Bear	aran IIIIa
3.9	1704	d. Line surveyed west from Langenoury to the south side of the Bear	ver mus.
4.9	1713	Miles from	Feet above
		Portage la Prairie	
7.0	1654	Red Deer Horn Creek, bed 185.0	1721
		Surface 188.0	1729
0.0	1521	Surface 195.0	1726
1.8	1468	Big Cut Arm Creek, bed	1651
		Surface	1720
32.7	134.	Surface	1709
12.9	1342	Crescent and Leech lakes, a few miles north of this	
		line, approximately	1679
64.0	1468	Surfa :e 220.0	1763
0.2.0		Surface	1816
66.0	1533	Surface	1863
67.6	1593	Ravine, bottom	1882
73.0	1638	Surface, end of survey 237.5	1919
80.1	1681	This line ends in the west part of T. 23, R. 7 W. from the s	econd initial
00.1	2., 1	meridian, between the Beaver Hills on the north and the Pheas	ant Hills on
Railwe	ay).	me soun, and about inteen innes east of the File Hills.	
4			

We surreyed northwest from Langenburg, passing northeast and north of the Beaver Hills.

I	Miles from Portage la Prairie.	Feet above
Summit		1774
Surface	212.0	1721
Armstrong's Coulée, first crossing, bed	213.9	1686
" second crossing, bed	217.4	1652
Yorkton	222.5	1633
Mill Creek (South branch of White Sand Rive	er),	
bed	223.3	1585
Surface	226.0	1620
Summit	231.0	1697

Miles from Portage to Prairie.	Feet above
Creek, bed 233.1	1654
Big Bone Creek (or Little White Sand River), bed 23315	1651
Surface 233.0	1690
Owl Creek, bed 240:2	1683
Surface 243.0	1709
Clair Creek, bed 244.5	1691
Small lake 245.7	1711
Surface 252.0	1747
Chippewa Creek, bed	1736
Surface 256.5	1770
Fern Creek, bed 256.3	1747
Surface 260-0	1781
Bear Creek, bed 262:7	1762
Spring Creek, bed 265.3	1785
Surface 270.0	1820
Water-course, bed	1813
Surface 273.0	1825

Along its last forty miles this line lies from two to seven miles southwested White Sand River. It terminates near the north side of T. 30, R. 10 W. from the second initial meridian, a few miles north of the Beaver Hills and about twenty-five miles east of the Big Touchwood Hills.

REGINA & LONG LAKE RAILWAY.

From R. M. Pratt, engineer, Winnipeg.

	Miles from Regina.	Feet above
Regina, junction with the Canadian Pacific Rail-		
way, 356.6 miles from Winnipeg	0.0	1885
Qu'Appelle River, low water, 1595; grade	21.4	1609
End of track	99.9	lei(w;
Arm of Long Lake here, in sec. 23, T. 20, R. 21,		
water		1598
Honglaketon at the southeast and of the main lake	a. is about	thron mile

[Longlaketon, at the southeast end of the main lake, is about three mile farther northwest.]

NORTHWEST COAL & NAVIGATION COMPANY'S RAILWAY.

From Dr. George M. Dawson, of the Geological and Natural History Sung of Canada.

or Canada.		
	Miles from Dunmore.	Feet above the sea.
Dunmore, junction with the Canadian Pacific Rail-		
way, 652.8 miles from Winnipeg	0.	2405
Bull's Head Creek, grade on bridge	2.	2314
Seven Persons River, grade on bridge	16.	2446
Crossing the west line of T. 11, R. 8, a summit of		
grade	27.	1) == =.) = f f =

14. M.

Entering Depressio (rossing t

Depression Crossing th

Summit of Lethbridge This elevation germined by M7 feet) at the metal surface

From levelling (Saint Paul ; fr 1818 Azassiz,

Lakes on the Otter Tail La Red River in Mouth of Pel Mouth of th Wahpeto Mouth of the

Lake Travers high water Red River at Red River at flood, abo

Surface of grounded River at and high water (ran

At Belmont (for water (ran Mouth of Red I low and hi Mouth of Pemb

739; ordine low and hig 10

4		-	_
1	4	Э	E

APPENDIX	II.

	_mean-		ALLEADIA III		110 4
Foot above the sea.	Entoring the F	ortheas		Dunmore.	Feet above the sea. 2592
1651					2562
1690					2614
1683	4	64			2609
1709	46	64	T. 9, R. 16,	78.	2677
1691	as a	6.6	T. 9, R. 17	. 84.	2707
1711	44	46	T. 9, R. 18	90.	2768
1747	Depression, gr	ade		91.	2751
1736	Crossing the w	est line	of T. 9, R. 19	96.5	2806
1770	41	66	T. 9, R. 20	103.	2877
1747	Summit of gra	de		. 106.	2999
1781	Lethbridge			. 109.	2954
1762	This elevation	proves t	he approximate correctness	of that b	arometrically
1785	etermined by Dr	. Dawson	n, before this railway was b	uilt, for the	e Belly River
1820	fill feet) at the "	Coal Br	inks," about a mile southwe	est of Leth	bridge. The
1813	eneral surface of	the coun	try here is 250 to 300 feet ab	ove the riv	er.
1825					
	the sea. 1654 1651 1690 1683 1709 1651 1711 1747 1776 1776 1777 1781 1762 1785 1820 1813	Feet abors the sea. 1654 1651 1690 1680 1709 1661 1717 1747 1776 1776 1777 1781 1781 1782 1785 1820 1830 1830 1831 1840 1851 1851 1854 1855 1856 1857 1856 1858 1858 1858 1858 1858 1858 1858	Feet above the sea. 1654 Entering the northeast 1654 Depression, grade 1680 1709 4 4 1747 Depression, grade 1747 Tropersion, grade 1776 1776 1776 1776 1777 1778 Lethbridge 1778 Lethbridge 1778 1781 Lethbridge 1782 1820 1876 1876 1876 1877 1878	Entering the northeast corner of T. 10, R. 11	Test above the sea. Miles from Dunmore. 1654 Entering the northeast corner of T. 10, R. 11 40 40 1651 Depression, grade

DRAINAGE SYSTEM OF THE RED RIVER OF THE NORTH.

From levelling by U. S. engineers, under the direction of Major C. J. Allen, Saint Paul; from railway surveys; and from the U. S. Geological Survey of the Agassiz.

a. Red River.	
	Feet above the sea.
Lakes on the Otter Tail River in Becker county, Minnesota	
oner Tail Lake	1315
Red River in Fergus Falls, descending 80 feet, approximately	1210-1130
Mouth of Pelican River, about	1115
Mouth of the Bois des Sioux River, Breckenridge and	
Wahpeton	943
Mouth of the Bois des Sioux River, highest flood, about	958
Lake Traverse, head of the Bois des Sioux River, low and	
high water	971-976
Red River at McCauleyville and Fort Abercrombie	910
Red River at McCauleyville and Fort Abercrombie, highest	
flood, about	934
Surface of ground at Fort Abercrombie	937
und River at Moorhead and Fargo, bed, 862; ordinary low	
and high water, 870-885 or 890; extreme low and high	
water (range, 32 feet)	866-898
At Belmont (formerly Frog Point), extreme low and high	
water (range, 50 feet)	797-847
Mouth of Red Lake River, Grand Forks, bed, 779; extreme	
low and high water (range, 44 feet)	784-828
Mouth of Pembina River, Pembina and Saint Vincent, bed,	
739; ordinary low and high water, 753-782; extreme	
low and high water (range, 40 feet)	748-788
10	

ven miles southwest d of T. 30, R. 10 W. from eaver Hills and about

peg. Miles from

the sea. Regina. 1885 0.0 1609 21.4 1606 22.2 1598 22.2 e, is about three mile

Feet above

RAHLWAY. atural History Surve

Feet above Miles from the sea Dunmore. 24(6) 0. 2314 2. 2446 16. 2772 27.

	Feet above the sea.
At Emerson, on the international boundary, ordinary low	riic iég
water and extreme high water	750-787
The following elevations of the Red River at Winnipeg and	northward ar
derived from surveys for the Canadian Pacific Railway, being in	1 Considerali
part from the published report of Sandford Fleming, engineer	in chief 1904
p. 269, from which a uniform subtraction of six feet is here m	ade to accon
with the revised profile of this railway.	
Mouth of Assiniboine River, Winnipeg, extreme low water,	
724; ordinary summer stage, 730; ordinary spring floods,	
740-745; high water, 1882, 750; do., 1860, 759; do., 1852,	
761; do., 1826, 763; general level of the land surface,	
758; extreme low and high water (range, 39 feet)	724-763
At the Louise bridge, Winnipeg, extreme low water, 723;	
ordinary spring floods, about 740; high water, 1882,	
749; do., 1826, 763; general level of the land surface, 756; extreme low and high water (range, 40 feet)	M 113 m
	$\widetilde{f}(\underline{x}_i) = \widetilde{f}(y_i)$
At Saint Andrew's church, extreme low water, 715; ordinary spring floods, about 735; high water, 1852, 745; do., 1826,	
753, nearly the same as the general level of the land	
surface; extreme low and high water (range, 38 feet)	Mar as
At Lower Fort Garry (the "Stone Fort"), extreme low water,	715-753
711; ordinary spring floods, about 730; high water, 1852,	
736; do., 1826, 746; general level of the land surface,	
752; extreme low and high water (range, 35 feet)	711-746
At West Selkirk, extreme low water, 710; ordinary spring	(11-140)
floods, about 720; high water, 1852, 726; do., 1826, 732;	
general level of the land surface, 739; extreme low and	
high water (range, 22 feet)	710-732
At Saint Peter's church, general level of the land surface,	
730; extreme low and high water (range, 15 feet)	709-724
Lake Winnipeg, mean, 710; extreme low and high water,	
approximately	708-710
b. Pembina River.	
Whitewater Lake, low and high water	
'At bridge of the Manitoba & Southwestern Railway, near	
Little Pembina station	Into
Divide between the Souris and Pembina Rivers, in Lang's	
Valley	1364
Bone Lake in Lang's Valley	1357
Grass Lake and Pelican Lake	1355
(Range of Pelican Lake from low to high water, 3 feet.)	
Lakes Lorne and Louise, about	1345 1335
Rock Lake, about	133)
At the Marringhurst bridge, about	130
Swan Lake, about	
Rivière	1287
Alviere	1201

At the M 22, T. On the in

At the "Dako about At the Wa

At the Sai At Neche, Mouth of At bridge Junction high v

At bridge 1209; Mouth of t foregoi At bridge o Brande Mouth of t At outcrop

about . approxi At Portage miles so the Hue At Portage 1 when th

waters i

This rise east. flowed before Big Slough, e close so

water, 84 flood of At Pratt's I Prairie, c and high At centre of

of Long In lot 230, Ba At St. Franco

At crossing of

the sea,		Feet above the sea.
y low 750-787	At the Mowbray bridge, on the line between secs. 21 and	ine sea.
and northward an	22 T. 1, R. 8, about	1235
eing in considerable	On the international boundary, about	1125
ineer in chief, 1890.	At the "fish trap," seven miles west of Walhalla, North	
here made to accord	Dakota (fall, 7 feet in an eighth of a mile), estimated	
1010 ment to accold	about	1050-1043
water,	At the Walhalla bridge, low and high water	934-943
floods,	At the Saint Joseph bridge, seven miles east from the last	865
, 1852,	At Neche, bed, 810; low and high water	813-832
urface,	Mouth of Tongue River, about	770
724-763	At bridge of the Duluth & Manitoba Railroad	757
r, 723;	Junction with the Red River, Pembina, extreme low and	
, 1882,	high water	748-788
surface,	·	
)	c. Aminiboine River.	
rdinary		
0., 1826,	At bridge of the Manitoba & Northwestern Railway, bed,	
he land	1209; water	1314
feet) 715-750	Mouth of the Qu'Appelle River, about 17 miles south of the	1001
w water,	foregoing.	1264
er, 1852,	At bridge of the Canadian Pacific Railway, 13 miles east of	
surface,	Brandon Brandon	1161
t) · · · · · · 711-740	Mouth of the Souris River, approximately	1100
y spring	At outcrop of Niobrara limestone in sec. 36, T. 8, R. 11,	
826, 732;	about 3½ miles east of the mouth of Cypress River,	1000
low and	approximately	
710-732	miles southwest from the town, near the former site of	
surface,	the Hudson Bay Company's fort	842-850
t) 709-724	At Portage la Prairie, extreme high water, May 3-15, 1882,	
h water,	when the river overflowed here, sending part of its	
708-713	waters north to Lake Manitoba	854
	This rise was caused by an ice jam a few miles farther	
	east. It is said that the river had previously over-	
1632-1657	flowed here to Lake Manitoba about twenty years	
way, near	before (probably in 1860).	
16(6)	Big Slough, occupying a deserted channel of the Assiniboine	
in Lang's	close south of Portage la Prairie, ordinary stage of	
1364	water, 849; in ordinary spring floods, 850; in the great	
1857	flood of May, 1882, 854; range, 5 feet	849-854
135	At Pratt's Landing, 21 miles southeast from Portage la	
er, 3 feet.)	Prairie, ordinary low and high water, 840-849; lowest	
134	and highest stages	837-852
1335	At centre of lot 142, Baie St. Paul, near the southeast end	
1330	of Long Lake	796
1910	In lot 230, Baie St. Paul	779
ilway, La	At St. François Xavier church	765
1287	At crossing of the Winnipeg meridian, in Headingly	757

At Headingly, 12 miles farther east, ordinary low and high	the sea,
water	
Mouth of Sturgeon Creek	
At Saint James, ordinary low and high water	736-754
728-742; extreme low and high water	
d. Lakes on the Qu'Appelle River.	
From H. Y. Hind; referred to sea level approximately by coelevations determined by levelling.	mparison nito
elevations determined by levening.	Feet above
	the sea.
Sand Hill Lake	W.CF()-1
Divide in glacial water-course between the Elbow of the	
South Saskatchewan and this lake	
Buffalo Lake	
Qu'Appelle River at bridge of the Regina & Long Lake	
Railway	
Long Lake, tributary to the Qu'Appelle River	1598
Fishing Lakes	
Crooked Lake	1389
Round Lake	1364
Junction of the Qu'Appelle with the Assiniboine	1264
e. Souris or Mouse River.	
On the international boundary, crossing from Assiniboia	
into North Dakota, 215 miles west of the Red River,	
about	1650
At Minot, North Dakota	1535
At Towner, North Dakota	1445
Crossing the international boundary 170 miles west of the	
Red River, about	1400
At Plum Creek, Manitoba, about	1335
At the Elbow west of Lang's Valley, 21 miles east-southeast	t
from the last, about	1265
At Gregory's mill, in sec. 34, T. 6, R. 18, five miles north from	
tle last, head 8 feet, about	1210-1202
At Souris City	1164
At Milford	111:
Junction with the Assiniboine, about	1100
was view with the regularione, appearing a service ser	
ALTITUDES ON THE CANOE ROUTE FROM LAKE SUPERIOR TO LAKE	

Determined by levelling by S. J. Dawson in 1857 and 1858, and published Hind's Narrative of the Canadian Exploring Expeditions, London, 1860, vo. pp. 399–402; corrected approximately by comparison with the survey of Canadian Pacific Railway.

Mouth Supe Mountai tiqu

Feet above

(incl Rocky p ascer Nine 12)

Little Dog Great Dog to Gr Summit of

sand Highest 1 Portag "The surp

in s Great Dog on this Mouth of I Cold Water

leve

Height summit of The highest Height of route... The po

Prairie por

" pass small avanne Lai tireat Savan feet to t Thousand La

on the r Thousand L high wa The Sein

to Rai feet, a falls 3 OBA.

		1,100		
	Feet above	a. From Lake Superior to the Lake of	the Woods.	
d high	754-764		Miles from	Feet above
			Lake Superior.	the sea.
	745 736-754	Mouth of the Kaministiquia River, Lake		
water	100-144	Superior	0.0	602
water,	724-763	Mountain portage (Kakabeka Falls), Kaminis-		
	1 = 1-100	tiquia River, 248 rods, ascending 119 feet		
		(including 14 feet of rapids below the alls).	20.2-30.0	681-800
		Rocky portage (or Ecarté portage), 148 rods,	00 0 00 7	900 949
by con	aparison with	ascending 63 feet	30.2-30.7	800-863
		Nine portages, ascending successively 61,		
	Feet above the sea,	12½, 7, 10, 10, 3, 3, 3, and 15 feet, intervene		
	1685	between the last and Little Dog Lake.	*0 0 *0 *	1000
of the		Little Dog Lake, 1.2 miles across on this route.	52.3 - 53.5	1002
	1704	Great Dog portage, 13 miles, ascending 348 feet,	59 5 55 0	1002-1350
	1635	to Great Dog Lake Summit of this portage (a broad and massive	53.5-55.2	1002~1330
g Lake		sand ridge)	54.0	1470
	1595	Highest part of this sand ridge, east of the	0110	* 110
	1598	portage path, about	54.0	1500
	1504-1500	"The great falls of Little Dog River are	.,,,,	1000
	1389	surprisingly beautiful. The difference in		
	1364	level between Little and Great Dog Lakes		
	1264	is descended by the foaming torrent		
		in six successive leaps."		
		Great Dog Lake, 90 feet deep, crossed 107 miles		
		on this route to the mouth of Dog River	55.2-66.0	1350
ssiniboia		Mouth of Prairie River, tributary to Dog River.	98.8	1378
ed River		Cold Water Lake, crossed 0.2 mile on this route.		1381
• • • • • • •		Prairie portage, 21 miles, ascending 157 feet, to		
		Height of Land Lake	102.1-104.6	1381-1538
st of the		Summit of this portage, about		1570
		The highest land there within view is about		1600
• • • • • • •		Height of Land Lake, crossed 0.2 mile on this		
		route	104.6-104.8	1538
southeas		The portage from this to Savanne Lake		
orth from		' passes over a low sandy ridge supporting		
		small pine."		
• • • • • • • • • • • • • • • • • • • •	22.00	Savanne Lake, crossed 12 miles on the route 1	105.4-106.9	1522
	1114	Great Savanne portage, 11 miles, descending 32		
	1100	feet to the Savanne River	106.9-108.4	1522-1490
	110	Thousand Lakes (Lac des Mille Lacs), 213 miles		
		on the route	121.6-143.4	1485
	KE WINNIPIO, I	Thousand Lakes (Lac des Mille Lacs), low and		
er.		high water, approximately		1483-1488
d 1858.	and published	The Seine River, outflowing from this lake		
as. Lond	lon, 1860, veli	to Rainy Lake, has a total descent of 368		
with th	he survey of the	feet, approximately. Hind states that it		
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		"falls 350 feet by twenty-nine steps vary-		

Miles from Lake Superior.	Feet above
ing in altitude from three to thirty-six	rite self
feet."	
Baril Lake, on the head stream of Sturgeon	
River, crossed 8 miles on the route 143.6-151.6	1487
Brulé portage, 84 rods, descending 47 feet 151.6-151.9	1487-1440
Upper Brulé Lake (or Cannibals' Lake), 8 miles	
on the route	1440
Lower Brulé Lake, 41 miles on the route 159.9-164.1	1437
Great French portage, 14 miles, descending 100	
feet to French Portage Lake164.1-165.8	1437-1337
French Portage Lake, 11 miles on the route 165.9-167.4	1337
Pickerel Lake, 13 miles on the route 169.9-182.9	1335
Pickerel portage, 104 rods, descending 7 feet to	
Doré Lake182.9-183.2	1336 1329
Doré Lake, 17 miles on the route 183.2-185.0	1329
Deux Rivières portage, 128 rods, descending 117	
feet to Sturgeon Lake 185.0-185.4	1329-1212
Sturgeon Lake, 231 miles on the route185.4-208.6	1212
First Sturgeon rapids, descending 4 feet in 44	
rods 208.6-208.7	1212 - 1208
Second Sturgeon rapids, portage 12 rods,	
descending 6 feet 209.0	1208-1202
Island portage, 12 rods, descending 10 feet 221.2	1197-1187
Nequanquon Lake (or Lac la Croix), 8 miles on	
the route	1186
Rattlesnake portage, Namekan River, 20 rods,	
descending 12 feet	1184-1172
Crow portage, 32 rods, descending 10 feet 238.6-238.7	1171~1161
Grand Falls portage, 24 rods, descending 16 feet. 245.2-245.3	1158-1142
Foot of Grand rapids, Namekan River 248.8	1127
Lake Namekan, 6½ miles on this route251.3-257.8	1126
Rainy Lake, 38 miles on this route	1117
" low and high water, approximately	1115-1120
Rapids, Rainy River, ½ mile, descending 3 feet301.3-301.8	1117-1114
Chaudière Falls, close east of Fort Francis,	
portage 32 rods, descending 23 feet303.3-303.4	1114-1091
Maniton rapids, descending 2½ feet in 60 rods336.2-336.4	1081-1078
Long Sault, descending 3 feet in mile 342.9-343.1	1075-10%
Lake of the Woods, crossed 72 miles on this	
route	1060

The difference winnipeg de missy surve

Lake of the Control of the Portal Les Dalles Grand Déterne Jau Charette I Terre Blasse feet... Cave rapic Month of I De Fisle po

Chute à Ja
descen
Foint des I
feet...
Point aux 0
rods, de
Roche Brul

Roche Brul Slave Falls, Barrier Fall Otter Falls, Seven 1 8, and Foot of the

Bonnet Lak Bonnet port Cap de Bon feet.... Big Bonnet feet....

Petit Roche White Mud 1 Silver Falls | rods, des Pine portage, At Fort Alex

Mouth of Riv and high There are thus ween the Lake

s from Feet above Superior. the sea.

3-151.6 1487 3-151.0 1487-1440 9-159.9 9-164.1 1-165.8 148" -100" 9 - 167.49-182.9

9-183.2 1336 1329 2-185.0 1329 .0-185.4 1329-1212 4-208.6

209.0 - 1208 - 1209 $221\cdot 2 - 1197\text{--}1187$ 225-233 1186

.2-235.3 1184-1172 .6-238.7 1171-1161 .2-245.3 1158-1142 248.8 1127 .3-257.8 1126 .3-301.3 1117

..... 1115-1120 .3-301.8 1117-1114 .3-303.4 1114-1091 .2-336.4 1081-1078 .9-343.1 1075-1070

.1 - 453.1

1437 1:37 1336

1212 .6-208.7 1212-1208

1060

ween the Lake of the Woods and Lake Winnipeg.

b. Winnipeg River.

The difference in elevation between the Lake of the Woods and Lake Winnipeg determined by this survey agrees exactly with that found by the pilway survey. Miles from the

	Milles from the		
	Lake of the	Feet above	
Lake of the Woods, low and high water, 1057-	Woods.	the sea.	
1063; mean		1000	
Rat Portage, 52 rods, descending 16 feet		1060	
Les Dalles rapids, descending 3 feet in 1 mile.		1060-1044	
. , , , , , , , , , , , , , , , , , , ,		1043-1040	
Grand Décharge, descending 6 feet in 1 mile		1038-1032	
ferre Jaune portage, 20 rods, descending 22 feet		1029-1007	
Charette Décharge, descending 34 feet in 8 rods		$1006\frac{1}{2}$ -1003	
ferre Blancke portage, 40 rods, descending t			
feet		1002 - 994	
Cave rapids, descending 24 feet in 8 rods		~993}-991	
Mouth of English River, approximately		987	
Del'Isle portage, 8 rods, descending 34 feet	57.0	9861-983	
thate à Jacques portage [Jack's Falls], 12 rods	,		
descending 13 feet	80.1	979-966	
Point des Bois portage, 52 rods, descending 10	}		
feet	89.7-89.9	9641-954	
Point aux Chênes portage [the Upper Falls], 20)	•	
rods, descending 20 feet	90.0-99.1	954-934	
Roche Brulé portage, 12 rods, descending 8 feet		933-925	
Save Falls, portage 120 rods, descending 20 fee		924-904	
Barrier Falls, portage 8 rody, descending 5 feet.		902-897	
ofter Falls, descending 3 feet in 4 rods		895-892	
Seven portages, successively 10, 8, 54, 8, 3		0011-002	
8, and 44 feet, follow.	,		
Foot of the seventh portage	116.2	826	
Bonnet Lake, 41 miles across on this route		823	
Bonnet portage, 4 rods, descending 7 feet		823-816	
Cap de Bonnet portage, 16 rods, descending 7		020-010	
feet		011 060	
Big Bonnet portage, 200 rods, descending 34		814-809	
		0	
feet		805-771	
Petit Roche portage, 52 rods, descending 8 feet.		770-762	
White Mud portage, 60 rods, descending 13 feet		75 8- 745	
Silver Falls [or Lower Falls], two portages, 92	2		

744 - 722Pine portage, 48 rods, descending 8 feet......150.25-150.4 720 - 712At Fort Alexander..... 710 Mouth of River, Lake Winnipeg, mean, 710; low

and high water, approximately..... 163.2708-713 here are thus twenty-seven portages (the two décharges being included)

SASKATCHEWAN RIVER.

From surveys of the Canadian Pacific Railway; of the Geological and Natural History Survey of Canada, by Dr. G. M. Dawson, R. G. McConnell, and J. B. Tyrrell; and of the Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind.

H. Y. Hind.	10
	Feet above the sea.
Bow River at the Gap, where it issues from the Rocky	end sca.
Mountains, about	4215
Bow River at Calgary, mouth of the Elbow River	3390
" at the Blackfoot Crossing, near the centre of T.	
21, R. 21	2016
Belly River at the "Coal Banks," Lethbridge	2717
Confluence of the Bow and Belly Rivers, forming the South	
Saskatchewan	2010
South Saskatchewan River at Medicine Hat, low and high	
water	2137-2154
South Saskatchewan River at mouth of Red Deer River	1958
in T. 22, R. 18, long. 108° 27′	1782
at the Elbow	1619
North Saskatchewan River at Rocky Mountain House and	
mouth of Clearwater River, about	3150
North Saskatchewan River at mouth of Brazeau River	2837
at big coal seam (27 feet thick,	
but including two feet of shale), Goose Encampment,	
long, 114°30′	2307
North Saskatchewan River at proposed crossing of the	
original line of the Canadian Pacific Railway, long. 114°	21%
North Saskatchewan River at Edmonton, about	2006
Edmouton, 200 feet above high water level of the river,	
about	22310
North Saskatchewan River at Victoria, near mouths of Egg	
and Smoky Creeks	1871
North Saskatchewan at Fort Pitt	1700
Junction of the South and North Saskatchewan Rivers,	
estimated	1200
Cedar Lake	824
Cross Lake	818
Head and foot of Grand rapids of the Saskatchewan,	
extending from about four and a half to two miles above	
its mouth (fall stated by Hind to be 43) feet in these two	
and a half miles, the upper 28½ feet being passed by a	
portage a little more than a mile long), approximately	765-720
Lake Winnipeg, mean, 710; low and high water, approxi-	1000-120
mately	708-713
matery	100~110

The following

Lake Wir Great and Sea River about Pipestone end of Sipi-wesk

Sipi-wesk Grand rap steep of Split Lake Gull Lake Lake, Twelve-fee

Lake, a Foot of Brown little rithe Two mouth Foot of First by the

about.

AUTITUDES ON

From reports
and the U.S.
comparison with

Lake Super approxi Mountain L South Lake, Water divid Lakes... North Lake, Guntlint La Saganaga La

Otter Track Knife Lake. Basswood La Lac la Croix Namekan La Rainy Lake

mately.

BA.

NELSON RIVER.

		NELSON RIVER.	
	ological and cConnell, and	The following estimated elevations of points on the Nelson Riv Met Bell (Reports of Progress, Geol. Survey of Canada, 1877-79).	er are by Dr.
	g Expedition	Notice and the second s	Feet above
axpiorm	g rapention,		the sea.
	Feet above	Lake Winnipeg	710
	the sea,	Great and Little Playgreen Lakes, also	710
Rocky		Sea River Falls, seventeen miles below Norway House,	
	4215	about	705-700
	3390	Pipestone and Cross Lakes, on the Nelson River at the north	
re of T.		end of Ross Island, about	665
• • • • • •	2595	Sipi-wesk Lake on Nelson River from lat. 55° to 55°20′, about	565
• • • • • •	2717	Grand rapid, "a descent of about fifteen feet in the form of a	
South		steep chute," four miles south of Split Lake, about	460-445
	2212	Split Lake, in lat. 56°15′ to 56°35′, about	440
id high		Gull Lake, eighteen miles below (east-northeast of) Split	
	2137-2154	Lake, about	· 450
ver	1958	Twelve-feet chute, forty-three miles below (east of) Gull	
27'	1782	Lake, about	200-188
	1619	Foot of Broad rapid, "two miles wide, and full of knobs and	
use and		little ridges of gneiss," extending five miles next below	
	2150	the Twelve-feet chute, or 116 to 111 miles from the	
er	2837	mouth of Nelson River, about	125
t thick,		Foot of First or Lowest Limestone rapid, about ninety miles	
npment,		by the course of the river above its mouth, probably	
	2307	about	50
of the		and the second s	00
ong. 114°		STITUDES ON THE INTERNATIONAL BOUNDARY FROM LAKE SUPER	RIOR TO THE
	2000	ROCKY MOUNTAINS.	
e river.		TO SEE THE WEST OF THE PARTY OF	C M.C 11
		From reports of N. H. Winchell, H. Y. Hind, G. M. Dawson, R.	
s of Egg		ad the U.S. Northern Boundary Commission; referred to	sea level by
	,	imparison with railway surveys.	Feet above
			the sea.
Rivers		Lake Superior, mean, 602; extreme low and high water,	
Mivers		approximately	599-604
		Mountain Lake, at head of Pigeon River	1652
		South Lake, at head of Arrow River	1535
tchewan		Water divide on the boundary, between South and North	
les abov		Lakes	1573
		North Lake, at head of waters draining to Rainy Lake	153 5
these tw		Gunflint Lake	1530
sed by		Saganaga Lake	1368
imately.		Otter Track Lake	1326
approx		Knife Lake	1322
	. 708-713	Basswood Lake	1244
		Lac la Croix (or Nequauquon Lake)	1186
		Namekan Lake	1126
		Rainy Lake, mean, 1117; low and high water, approxi-	
IV		mately	1115-1120
		11	1110-1110

	Feet above
7 1 6 4 W 1 1000 1 1 bish costs	the sea.
Lake of the Woods, mean, 1060; low and high water,	1055
approximately	1007-1066
Ridge twelve miles farther west, forming the divide on the	
boundary between the Lake of the Woods and Roseau	1
Lake	1088
Pine River	1047
Roseau Lake, about	1040
Ridge three miles west of Pine River	1070
Koseau River at Pointe d'Orme	976
Ridge twenty miles east of the Red River	1016
Ridge twelve miles east of the Red River	848
Emerson	790
Red River, ordinary stage, 752; low and high water	747-787
Gretna	829
Pembina Mountain, base and top	1030-1500
Pembina River, approximately	1125
General level of the adjoining country, about	1540
Lac des Roches in North Dakota, and divide between this	
lake and Badger Creek in Manitoba, about	1520
Turtle Mountain, according to Dr. G. M. Dawson's map	2150
" according to profile in report of the U. S.	
Boundary Commission	2000-2534
Souris River, first crossing, about	1400
" second crossing, about	1650
Coteau du Missouri, base and crest	1900-2140
Wood Mountain, highest portion on the boundary	2950-3075
" north of the boundary	3350
White Mud River	2550
Boundary Plateau	3000-3250
East fork of Milk River	2790
Wild Horse Lake	2850
Milk River, probably about	2600
West Butte, the highest of the Sweet Grass Hills or Three	
Buttes	6483
East Butte	6200
Trail from Fort Benton to Fort MacLeod	3548
North Branch of Milk River one mile north of the boundary,	
long. 113°	4173
Eastern base of the Rocky Mountains, long. 113°25', about	4500
Waterton Lake (or Chief Mountain Lake), crossed by the	
boundary in long. 113°52', in the east edge of the Rocky	
Mountains	4245
Rocky Mountains, summits in the vicinity of this lake, on	
the continental water-shed	.500-10.500

ADDITIONA

Mostly from inpart correct facility Railway Lake Nip Depressio Super Lonely La

This req

can shor bein Lake Saim as ma Lake Lans about-Lake Saint Lake Mani of Sain approx

Lake Win approx Lake Daup Swan Lake Divide betw Cedar Lake Pembina M Tiger Hills Big Tiger H

Brandon Hi Riding Mou Duck Moun Thunder Hi Churchill Ri S. 33° V

River... Was-kai-ow-River... Churchill Ri Churchill Frog portage

Woods, a flowing s The following a there noted an

arch of Sir John

Feet above the sea. water, 1057-1063 on the Roseau 1088 1047 1040 1070 976 1016 848 790 747-787 829 1030-1500 1125. 1540 en this 1520 2150 map.... he U. S. 2000-2534 1900-2140 2950-3075 3350 2550 3000-3250 2790 2850 2600 or Three 64836200 3548 oundary, 4173 about... 1 by the e Rocky

4245

. lake, on7,500-10,500

ADDITIONAL ALTITUDES IN MANITOBA AND ADJOINING PORTIONS OF CANADA. Mostly from reports of the Geological and Natural History Survey of Canada; hast corrected approximately by comparison with the Survey of the Canadian Pscific Railway. Feet above

	the sea.
Lake Nipigon (540 feet deep near Echo Rock)	915
Depressions in the line of water-shed northwest of Lake	
Superior	1500-1750
Lonely Lake (Lac Seul)	1232
This altitude, determined independently, probably	
requires some subtraction, for the description of the	
canoe route from Lonely Lake to Lake Saint Joseph	
shows that the latter is the higher, the difference	
being apparently twenty feet or more.	
Lake Saint Joseph (mean of ten barometric observations on	
as many days)	
Lake Lansdowne, near the head of the Attawapishkat River,	
about	960
Lake Saint Martin	794
Lake Manitoba (determined by levelling by H. S. Treherne,	
of Saint Paul, Minn.), mean, 809; low and high water,	
approximately	805-813
Lake Winnipegosis, mean, 828; low and high water,	
approximately	825-831 839?
Lake Dauphin	860?
Divide between Lake Winnipegosis and Cedar Lake	875?
Gedar Lake, on the Saskatchewan	824
Pembina Mountain, crest of the escarpment	1400-1500
Tiger Hills	1500-1600
Big Tiger Hill, north of Lang's Valley, about	1640
Brandon Hills	1550-1600
Riding Mountain, about	2000
Duck Mountain	
Thunder Hill	1900
Churchill River, 105 miles from its mouth, in the direction	
S. 33° W. (astr.), at the mouth of the Little Churchill	
River	705
Was-kai-ow-a-ka Lake, at the head of the Little Churchill	
River	936
Churchill River, 23 miles above the mouth of the Little	
Churchill	878
Frog portage, from the Churchill River to the Lake of the	
Woods, at the head of a chain of lakes and streams	1
flowing southward to the Saskatchewan, estimated	1200

The following altitudes, from Isle à la Crosse Lake to Lake Athabasca, which here noted as determined by Sir John Richardson (Arctic Expedition in sech of Sir John Franklin), probably require an average addition of about 200

	Feet above
Isle à la Crosse Lake, on the Churchill River	the sea.
Thence southward to Carlton House on the North Saskatch	
seventy miles above the junction of the South and North Saskatch	
[estimated 1200 feet above the sea], Richardson reports a descent	
hundred feet, across "an undulating country, but without	
acclivity."	ung mark
Professor Macoun states that Isle à la Crosse, Clear, and Buffalo	
on the same level," being stagnant water filled with green scum in	summer,
Methy Lake or Lac la Loche	1490
" (according to Captain Lefroy,	
cited by Richardson)	1500
Summit of Methy portage (also called Portage la Loche and	
the Long Portage), on the water-shed between the	
Churchill and Athabasea Rivers	1556
The "Cockscomb," on this portage at the crest of the bluff	
descending to the Clearwater River, tributary to the	
Athabasca	1534
Clearwater Rivor at the north end of this portage	900
Lake Athabasca	600
Altitudes determined by Dr. G. M. Dawson show the present l	
glacial lake bed now drained by the Peace River, and of its p	robable fi
avenues of outflow southeast to Lake Agassiz, as follows:	
Peace River at Dunvegan	1300
Top of river-bluff one mile from Dunvegan	2100
General level of the country in this vicinity	2200
Area of lacustrine silt in the basin of the Peace River 2	
The valley of this part of the river, eight or nine hundred feet de	
in a vast plain, from which, according to Richardson, "the Rock	y Mounta
are not visible, and no range of hills neets the eye."	
Water-shed between Peace River and Lesser Slave Lake	2430
Water-shed between Tow-ti-now River, a tributary of the	
Athabasca, and the North Saskatchewan, on the trail	Duar
from Athabasca Landing to Edmonton	2485

OBA.

	Feet above	
	the sea.	
	1300	
h Saskatch	ewan, abou	
th Saskatch		
s a descent	of about two	
without a		
and Buffalo	Lakes "a	
en scum in		
	1490	
n Lefroy,		
	1500	
oche and		
ween the	-	
	1556	
the bluff		
ry to the		
	1534	
	900	
	600	
he present		
and of its	probable fi	
s:		
	1300	
• • • • • • • • • •	2100	
	2200	
ver	2000-2500	
adred feet d		
, "the Roc	ky Mounta	
e Lake	2430	
ry of the	1	
. 41 - 421		

Gl